TEMPORARY SOIL NAIL SHORING

WSDOT I-405 RENTON TO BELLEVUE DESIGN/BUILD

WALL 7.15R SHORING

STRUCTURAL SHORING WALL CALCULATIONS

for

FLATIRON-LANE JOINT VENTURE
1400 Talbot Road South #500
Renton, WA 98055

This document was reviewed to ensure the design conforms to the requirments of the RFP and is compliant with the design of the permanent construction. The Engineer of Record for this document is responsible for the design and engineering recommendations provided.

I-405, Renton to Bellevue Widening & and Express Toll Lanes Project

DOCUMENT REVIEW

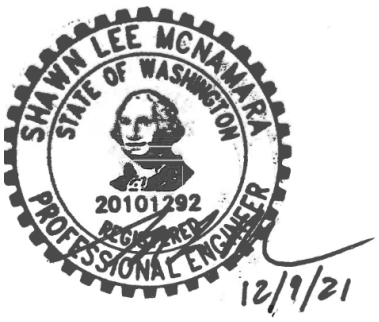
☒ APPROVED, NO EXCEPTION TAKEN
☐ APPROVED AS NOTED
☐ RESUBMIT, REVISE AS NOTED

REVIEWED BY: Todd Wentworth DATE: 6 Jan 22

Geotechnical engineering

Review is for general conformance with contract or design documents. Sole responsibility for correctness of dimensions, details, quantities, materials, and safety during fabrication and erection shall remain with the contractor.

REVISED December 9, 2021



FLATIRON | LANE
For Construction
1/10/2022

DTDS Job No. 20018

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1.0 DESIGN OVERVIEW

The purpose of this design submittal is for a temporary soil nail shoring wall for Structure 7.15R at the WSDOT Design/Build Renton to Bellevue Design Build Project.

The wall design is based on engineering methods and requirements contained in the following:

1) WSDOT Geotechnical Design Manual (GDM) M46-03.11 May 2015 and Addendum M46-03.12 Revision Chapters 6 & 15
2) WSDOT Design Manual M22-01.18, December 2019 and M22-01.05 June 2009
3) Federal Highway Administration (FHWA) Publication "Soil Nail Walls Reference Manual - Engineering Circular No. 7" (Publication No. FHWA -NHI-14-007)".

In general, this report provides a temporary soil nail shoring design following the steps provided in the FHWA Engineering Circular No. 7 “Appendix C: Design Example”

2.0 PROJECT REQUIREMENTS

An approximately 66' long soil nail wall up to 15.5' tall in height is planned for temporary shoring as part of this project. No underground utilities or permanent structures exist behind the wall that will impede the nails. There is however, an existing bridge abutment at the end of the wall that nails will be designed to avoid.

3.0 SUBSURFACE EXPLORATION AND DEVELOPMENT OF PARAMETERS FOR DESIGN

Temporary soil nail wall design parameters were taken from the 10-01-2020 "Released for Construction" Wall 7.15R Geotechnical Engineering Report prepared for the project by Wood Environmental & Infrastructure Solutions Inc. In particular, Table 6 (Engineering Stratigraphic Units) and Section A-A’ in Appendix C (of the above referenced Geotechnical Engineering Report) were used to represent the geologic cross section behind the soil nail wall. A subsequent boring B 1-2021 was drilled by FLJV in the nail zone behind the wall. This boring and its location is present in the Atlas memo in Appendix C. ~~In particular, boring logs R2B-22vw-17 and B-1-2021 were used to represent the soil for our shoring cross sections.~~

Table 6: Wall 7.15R Design Soil Properties

ESU	Soil Type (USCS Classification)	Corrected SPT Blow Count, $(N_1)_{60}$ (blows per foot)	Moist Unit Weight (pcf)	Effective Peak ϕ' (deg)	Effective Peak c' (psf)	Su (psf)	Liquefied Strength	
							ϕ' (deg)	c' (psf)
Cross Section A–A' [1]								
1A	SM	20	115	34	-	-	-	-
2A-1	OL	5	90	29[1]	-	370 [2]	-	-
2B	SM	5	110	29 [3]	-	-	3	100
2C-1[4]	ML/OL	8	110	28 [2]	-	800 [2]	-	-
2C-1	ML/OL	8	110	28 [2]		800 [2]	4	100
4A	SM/SP-SM	77	135	40	-	-	-	-

*Taken from Woods 10-01-2020 “Released for Construction Wall 7.15R Report for Cross Section A-A’

The profiles used for analysis are based on the stratigraphy from cross sections A-A' in the previous mentioned Wood's Geotechnical Engineering report in conjunction with boring Logs R2B-22vw-17, W-1-54, B-1-2021, and W-37cp-20. The entirety of the soil nail shoring is contained within ESU 1A. However, Global stability of the wall (Conducted by Atlas Geotechnical in Appendix C) is analyzed through layers containing ESU 2B, ESU 2A-1, ESU 4A and ESU 2C-1.

Per Appendix C Borings R2B-22vw-17, W-37 cp-20, and B-1-2021 show that the TNSW will retain only ESU 1A, loose to medium dense silty sand embankment fill, USCS designation SM~~— Atlas Wall Report "Boring R2B-22vw-17 shows that the TSNW will retain only ESU 1A, loose to medium dense silty sand embankment fill, USCS designation SM. Average SPT blow counts from this boring log indicate that ESU 1A is slightly denser than at the other boring locations used to characterize ESU 1A at RW 07.15R. There are no notable "soft" spots with excessive fines and/or low SPT blow counts, with the lowest value being 9 blows/ft at a depth close to Row3 nail elevations. The mean minus one standard deviation strength value from the RFU Geotechnical Report is adequate for characterizing ESU 1A behind the TSNW.

Boring R2B-22vw-17 is 0.8 wall heights in front of the wall, so it does not explicitly satisfy the GDM guidance that borings be in the load transfer zone, about 1.0-1.5 wall heights behind the wall. For this location, though, the retained materials are an embankment built specifically to support an Interstate highway. In our judgement, these fill soils are sufficiently uniform to allow using data from a nearby borehole despite it not being in the optimum position. The wall is only 67 feet long, so this single boring satisfies GDM exploration spacing requirement.

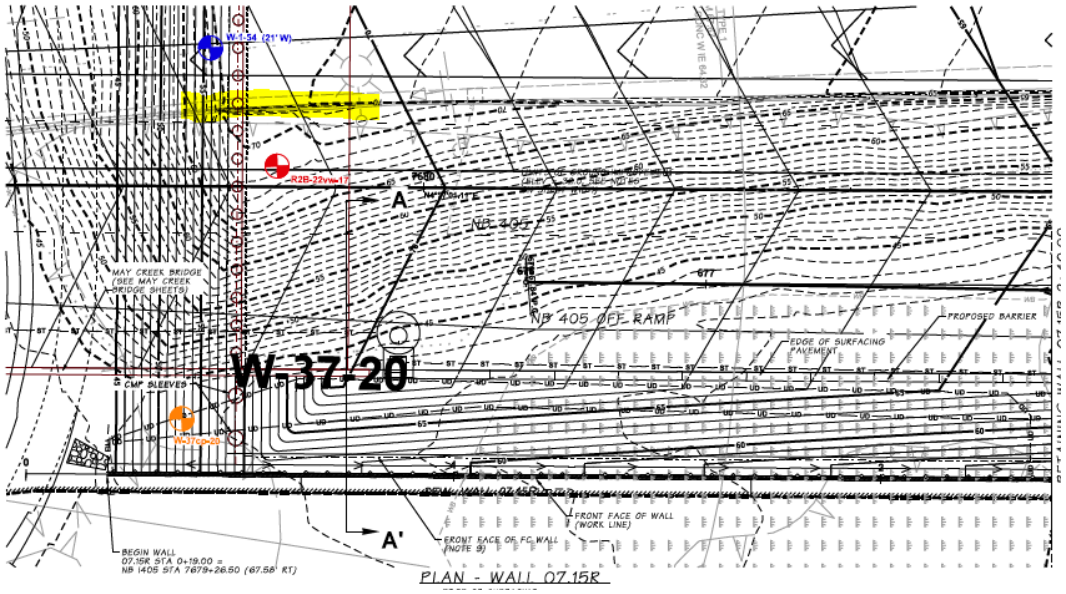
Additional explorations or laboratory testing beyond those summarized in the RFU RW 07.15R Geotechnical Report are not necessary according to GDM Section 15-7.2 (Jan 2019)"~~

Table 4: Summary of ESUs

Geological Unit Name	ESU	Description
Fill (Af)	1A	Embankment fill placed during existing bridge construction, comprising loose to medium dense Sand/Gravel
Organic Soils (Qp)	2A-1	Interbedded layers of organic rich materials consisting of medium stiff to stiff peat and organic silts
	2B	Interbedded layers of organic rich materials consisting of loose to medium dense silty sands
	2C	Interbedded layers of organic rich materials consisting of very soft to soft organic silts and clays
	2C-1	Interbedded layers of organic rich materials consisting of medium stiff to stiff organic silts and clays
Alluvium (Qal) and Recessional Deposits (Qvr)	3A/3B	Medium dense silt and sand
Recessional Lacustrine Deposits (Qvrl)	3E	Soft to stiff silt and clay
Advance Outwash (Qva)	4A	Interbedded dense to very dense gravel, sands and silts

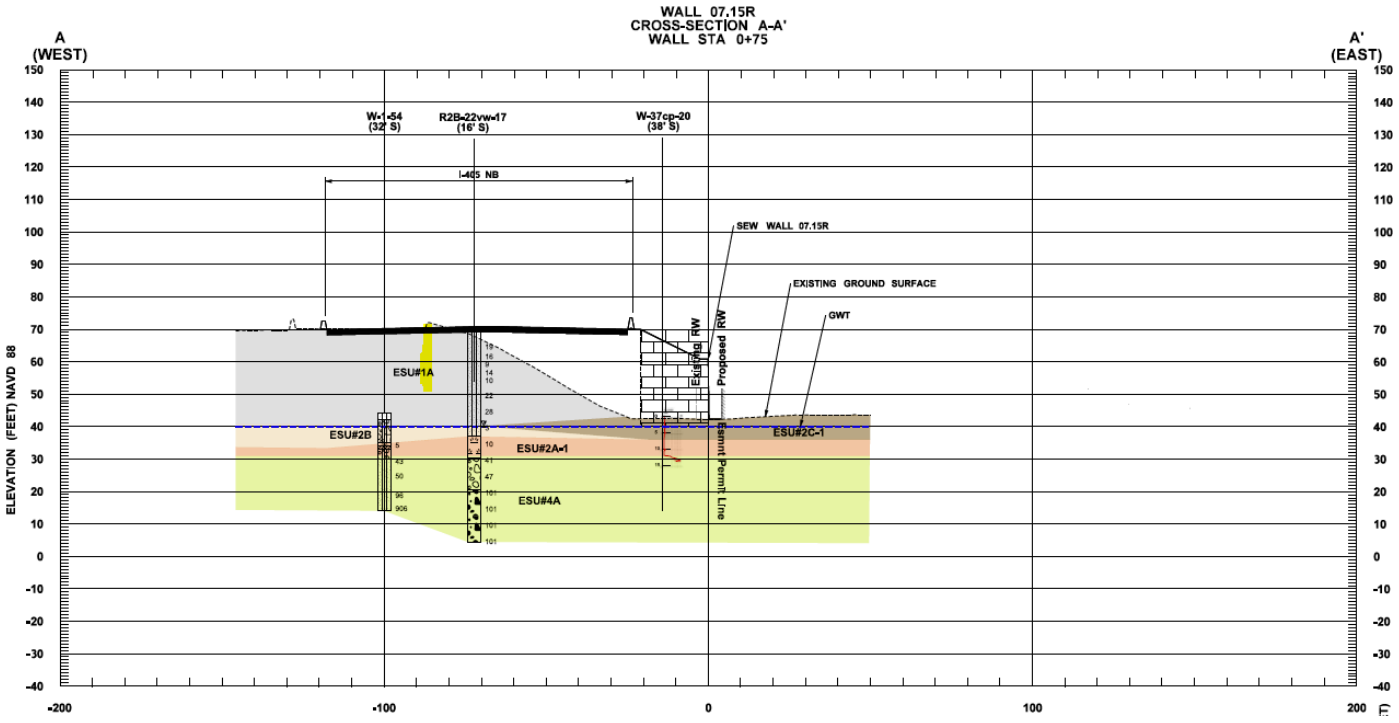
*Taken from Woods 10-01-2020 "Released for Construction Wall 7.15R Report

Site plan is shown below with the approximate soil nail shoring location highlighted in yellow.



*Taken from Woods 10-01-2020 "Released for Construction Wall 7.15R Report for Cross Section A-A'

Cross Section is shown below with the approximate soil nail shoring location highlighted in yellow.



*Taken from Woods 10-01-2020 "Released for Construction Wall 7.15R Report for Cross Section A-A'

4.0 LOAD DEFINITION

The permanent load acting on the wall includes the weight of the soils behind the wall. These parameters have been defined in Section 3.0. The live loads include those from freeway traffic moving behind the wall and routine construction traffic above the shoring system. Per Section 15-7.3.3 and 15-4.9 of the GDM a uniform traffic/live load of 250 psf will be added above the wall to address existing freeway and/or routine construction traffic moving behind the wall. Therefore, the wall cannot be loaded above standard highway loading.

Active, passive, and at-rest pressures derivation do not apply for soil nail wall design when conducting limit equilibrium analysis.

It is not anticipated that large equipment (such as a crane or other heavy equipment), material storage, or unusual temporary loadings, will be staged above the soil nail wall. Therefore the wall has not been designed for these loadings.

5.0 SOIL NAIL CONFIGURATION AND MATERIAL SELECTION

The temporary soil nail shoring wall height varies between 4 and 15.5 feet tall. Several analyses will be conducted along the wall length.

Vertical and Horizontal Spacing of Nails

- SH=SV= 5 feet
- This vertical max spacing results in 3 rows of nails at the deepest section

Vertical Spacing at Top and Bottom of Wall

The spacing between the first row and top of wall is selected as:

- SV0 = 2.5ft <=3.5 ft

The spacing between the deepest row and the bottom of wall is

- SVN = 2 ft <= 2 to 3 ft

Soil Nail Inclination

Because no utilities or obstruction exist behind the wall, the soil nail inclination is selected as:

- i = 15 degrees for all nails

Soil Nail Length

Soil nail length will vary per height analysis. Per GDM Section 15-5.7 Soil nail tendons shall be number 6 bar or larger and a minimum of 12 feet in length or 60 percent of the total wall height, whichever is greater.

Soil Nail Pattern on Wall Face

A “square” pattern is considered feasible for this design

Type and Mechanical Properties

Soil nails will be Steel Grade 75ksi bar. Per GDM 15-5.7, soil nail tendons shall be #6 bar or larger.

Corrosion Protection

As this is a temporary soil nail structure, corrosion protection of the nails is not required.

Bond Strength

Initial verification testing was conducted based on the original approved 7-20-2021 Wall 7.15 shoring plans. The two original and both of the subsequently installed verification nails failed to achieve the ultimate design bond strength of 15 psi (which was assumed based on rotary methods). A change in drilling method to auger methods was the most likely cause of the unsatisfactory bond strengths.

An ultimate bond strength of 7.5 psi was assumed for this revised wall design. The 4 previously conducted verification tests (as discussed above) achieved loading in this range. In addition, this value is within acceptable range of silty fine sand soils in the area per FHWA Table 4.4a for "Augured" Silty Sand and will be verified with the required testing described below.

An updated memo from Atlas geotechnical as well as the original (4 each) verification test info is contained in Appendix C. Two pre-production additional Verification nails will be installed (as shown on the updated plans) and tested prior to production. Proof testing to 150% (at the locations shown on the update plans) will be conducted during production drilling.

6.0 SELECTION OF RESISTENCE FACTORS

Safety factors for design were developed in accordance with Section 15-5.7 of the GDM and FHWA Circular No. 7. In general per the GDM, "T*he geotechnical designer shall design the wall at critical wall sections. Each critical wall section shall be evaluated during construction of each nail lift. To accomplish this, the wall shall be analyzed for the case where excavation has occurred for that lift, but the nails have not been installed. The minimum construction safety factor shall be 1.2 for noncritical walls and 1.35 for critical walls such as those underpinning abutments.*"

Table 1: Summary of Resistance Factors for ASD Verifications

STRENGTH LIMIT STATE	CONDITION	MINIMUM FOS REQUIRED
Overall Global Stability	Internal/External	1.3
Per GDM - Last Lift Stability	Internal	1.35
Nail Pullout	Static	2.0
Nail in Tension	Grade 75 ksi	1.8
Facing Flexure	Temp	1.5
Facing Flexure	Temp	1.5

Per Section 6.4 of the project GDM the temporary shoring wall has been designed assuming as critical. Therefore, all temporary cut analysis in SNAIL PLUS have been designed to a factor of safety to meet or exceed 1.35 when the last lift is cut but the nail has not been installed (per GDM 15-5.7) and all final global analysis have been designed to 1.3 (per GDM Section 15-4.12 and 15-7.3.2).

7.0 OVERALL STABILITY

7.1 Overview of Stability Analysis With SNAIL PLUS by Deep Excavation LLC

SNAIL PLUS is a two-dimensional, limit-equilibrium analyses based on the method of slices according to Morgenstern-Price (M-P) & Spencer methods for static condition. This program employs limit-equilibrium methods in accordance with the Project GDM Chapter 7 and Section 15.4.12. This program analyzes overall stability, both internal (slip surface through some soil nails) and external (slip surface around all soil nails) stability

A SNAIL PLUS user can perform a full design of a soil nail wall by selecting trial designs and repeating the analysis until strengths and capacities are verified. After the first run, the user can modify one or more of the design parameters (e.g. increase tendon length and/or diameter, decrease tendon spacing, thickening the facings etc.) and conduct new trials until stability requirements are met. SNAIL PLUS can search for various slip circles until one with the lowest factor of safety is found.

7.1.1 Data Entry with SNAIL PLUS

To model a wall in SNAIL PLUS, the user can enter points defining the initial, intermediate, and final configuration of the grades; the top surface of each soil layer; and the location of groundwater. The location of each point is defined by the horizontal coordinate X, and the vertical coordinate Y. The soil layers and groundwater are also defined by the horizontal coordinate X and vertical coordinate Y.

A summary of the properties of the soil nail wall and components used in SNAIL PLUS are presented below:

Parameter	Main Feature	Additional Descriptions
Nail Features	Solid Bars, Grade 75 ksi	Borehole Dia. 6 inches
Facing Thickness/Type	hi = 4 inches	shotcrete f'c = 4,000 psi
Reinforcing Grade/Type	Grade 60 ksi WWM 4"x4" W4.0 x W4.0	
Added Reinforcing	#4 Waler Bars	
Bearing Plate	7"x7"x3/4"	Grade 50, fy = 50 ksi

7.2 Results

Temporary Shoring for Wall 7.15R was evaluated at 2 different sections of the wall based on variations in the wall height and final slope configurations below. After trial runs, each design section was finalized to meet the required factors of Safety. The results of all analysis are summarized in the tables below. The full SNAIL PLUS input and output for all sections have been provided in Appendix A.

Table 2: Design Sections

Design Section	Wall Station	Start Station	End Station	Selection Criteria
1	0+24.53	0+17.5	0+52.5	15.5’ Max Wall Height
2	0+52.5	0+00 0+52.5	0+17.5 0+66.23	10’ Wall Hight with Max Slope Below

Soil nail wall design followed the requirements in Sections 15-7.3.2 and 15-5.7 of the Project GDM and *Geotechnical Engineering Circular No 7: Soil Nail Walls Reference Manual* (FHWA 2015). The design of the soil nail wall, soil nail lengths, spacing, size, etc., followed the *Geotechnical Engineering Circular No. 7, Soil Nail Walls – Reference Manual* (FHWA 2015) and verified that the calculated factor of safety (FOS) for the critical slip surface was greater than the minimum required FOS.

The initial 5’ tall unsupported cut will be evaluated per GDM Section 15-3.4.2.1 using test pits prior to construction. Notes have been added to the construction drawings regarding the test pits.

All analysis presented below meet or exceed the required factor of safety of 1.35 for the intermittent and final wall cuts and 1.3 for the final configurations (Global Analysis w/cut Below) required for a critical wall design.

7.2.1 Design Section 1 – 15.5’ Tall Section Wall Station 0+17.50 to 0+52.50

The results of the overall stability are summarized for this portion of wall in the table below.

Excavation Stage	Calculated FOS - MP	Calculated FOS - Spencer	Condition	Remarks
1	1.387	1.53	Temporary	1st Row Installed Second lift Exposed
2	1.464	1.393	Temporary	2nd Row Installed Third lift Exposed
3	1.537	1.546	Final	3 Rows Installed with Surcharge

The final nail design lengths, size, and required facing strength are summarized for this portion of wall below:

Row	Max Nail Head Force (kips)	Angle	Length	Size
1	12.12	15	32’	GR75 #7
2		15	32’	GR75 #7
3		15	14’	GR75 #7

7.2.2 Design Section 2 - 10' Tall Section Wall Station 0+0.00 to 0+17.50 and 0+52.5 to 0+66.23

The results of the overall stability are summarized for this portion of wall in the table below.

Excavation Stage	Calculated FOS - MP	Calculated FOS - Spencer	Condition	Remarks
1	1.361	1.564	Temporary	1st Row Installed Second lift Exposed
2	1.837	2.029	Final	2 Rows Installed with Surcharge
3	1.4242	1.405	Final	Global Analysis w/Cut Below

The final nail design lengths, size, and required facing strength are summarized for this portion of wall below:

Row	Max Nail Head Force (kips)	Angle	Length	Size
1	7.72	15	26'	GR75 #7
2		15	19'	GR75 #7

7.3 Verify Sliding and Overturning Stability

Overturning and sliding are generally not relevant to cut walls, however, the stability is maintained by using nails longer than .6H which has been done for this design. In addition, the soils directly beneath the soil nail wall do not present a sliding concern per FHWA Section 5.7.3. Per FHWA, Overturning of soil nail walls is not considered a realistic limit state in the manual.

7.4 Verify Facing Bending/Flexure Resistance

Facing calculations per FHWA Circular No.7 have been conducted and are included in detail in Appendix B. The proposed facing provided in Section 7.1.1 is adequate and results in a capacity greater than the required maximum nail head force.

The maximum nail head force of 12.12 kips from Design Section 1 was used for facing design.

7.5 Verify Facing Punching Shear Resistance

Facing calculations per FHWA Circular No.7 have been conducted and are included in detail in Appendix B. The proposed facing provided in Section 7.1.1 is adequate and results in a capacity greater than the required maximum nail head force.

The maximum nail head force of 12.12 kips from Design Section 1 was used for facing design.

7.6 External Stability per GDM 15-5.7

External and compound stability has been evaluated by Atlas Geotechnical per Section 15-5.7 of the GDM. Their discussion, analysis, and results are presented in Appendix C.

8.0 SERVICE LIMIT STATES

8.1 Wall Lateral and Vertical Displacements

Wall deflections induced by construction and operation can be estimated from correlations presented in FHWA Section 5.9.2. For a vertical soil nail wall with sandy soil behind it, it is expected that the maximum vertical and horizontal permanent deflections at the top or the wall will be approximately:

$H := 15.5\,ft$

$\delta_h := \frac{H}{500} = 0.372 \cdot in$ $\delta_v := \frac{H}{500} = 0.372 \cdot in$ PER FHWA TABLE 5.12

The wall deformations are expected to decrease to insignificant values over a distance D_{DEF} behind the wall. Considering the wall has no batter, the distance estimated as (FHWA Figure 5.16)

$C := 1.250$ SOIL DEPENDENT COEFFICIENT PER FHWA TABLE 5.12

$D_{DEF} := C \cdot H \cdot (1 - tan(0)) = 19.375\,ft$

$\delta_{h2} := .005H = 0.93\,in$ FHWA DEFLECTION CAUSE FOR CONCERN

Appendix A – Full SNAIL PLUS Analysis Input and Output

Appendix B – Soil Nail Facing Calculations

SnailPlus 2020: Report Output

Project: I-405 DB Bellevue to Renton

Company: My Company
Prepared by engineer: Shawn McNamara
File number: 1
Time: 10/18/2021 12:45:52 PM

File: C:\Users\shawn.mcnamara\DTDS\drilltechdrilling.com\DTDS Jobs - 20018 WADOT I-405 Renton to Bellevue, Seattle, WA, Flatiron Lane\09-Engineering\Wall 7.15R Shoring\DeepEx SNAIL Win\Reduced Bond 10-18-21\Wall 7.15 Shoring.SNLP

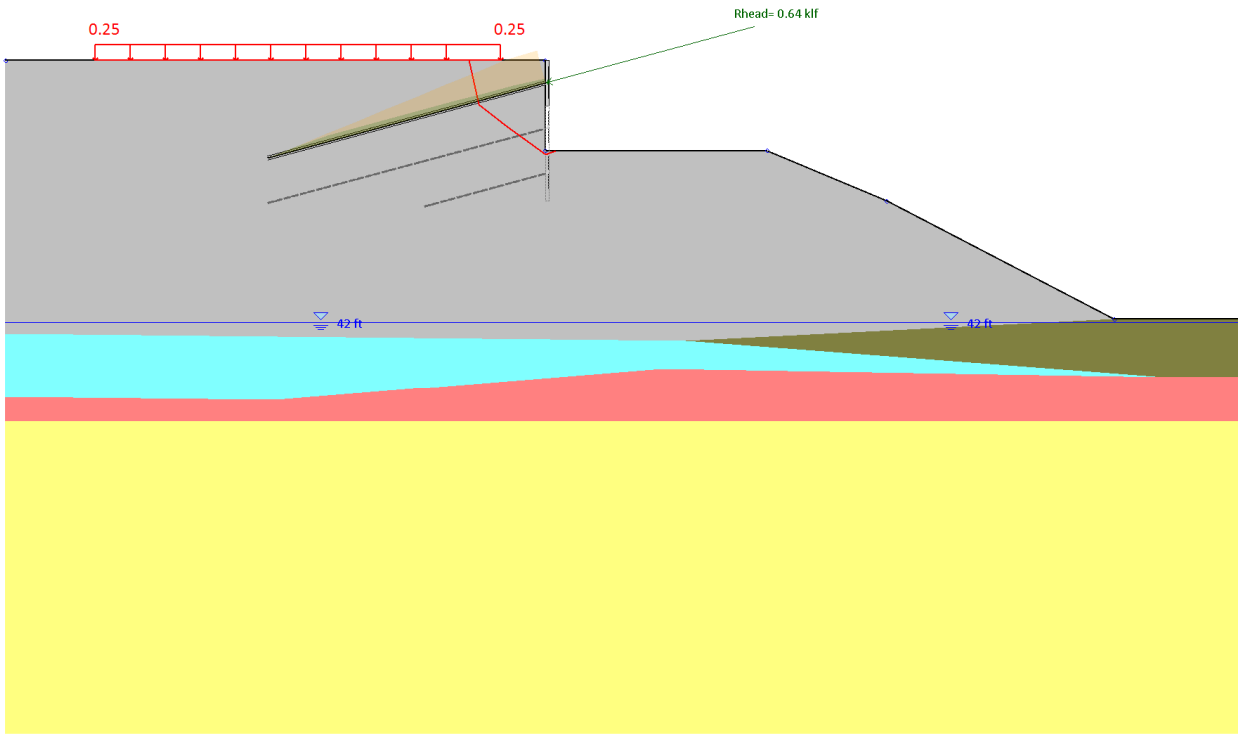
Quick analysis summary for design section: Design Section 1 - 15' M-P Sta. 0+17.

Design Section 1 - 15' M-P Sta. 0+17.5 to 0+52.5

ESU 4A (UND.)	135	0	-	40	0

Morgenstern-Price, FSsuggested.min = 1.35
Automatic search(Left exit pt: -8.486ft, 71ft)
(Right exit pt: 1.092ft, 61ft)

FS= 1.387



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.387	4.57	3.22	0.183	0.199	0.127	Yes	Yes
Install Nail 3	Calculated	1.464	10.96	7.72	0.438	0.477	0.304	Yes	Yes
Final Ex. Intern	Calculated	1.537	17.19	12.12	0.988	0.748	0.477	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.387	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Install Nail 3	Yes	1.464	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	1.537	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	25	0.183	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 3)	N/A		Service Facto	24.9	0.438	N/A	N/A	N/A
xL (-57 to -7.	xR (0.01 to 1	N/A		Service Facto	23.3	0.988	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term
Min required FS	1.35
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Automatic
Left limits	-57ft to -7.125ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N1	3: #7Gr.75	15	0	63.5	32	0	5	2.4235	12.12
N2	3: #7Gr.75	15	0	58.5	14	0	5	1.653	8.27
Nail 1	3: #7Gr.75	15	0	68.5	32	0	5	2.2385	11.19

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	55.5
4	37.9	55.5
5	63.1	42.4
6	80	42.4

Soil type property data

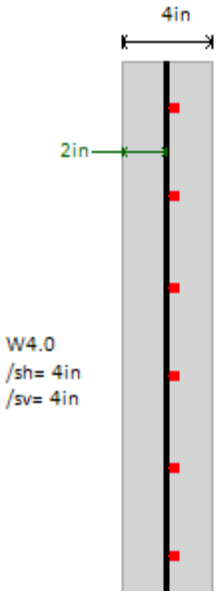
Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1A	115	115	34	0	N/A	7.5	
ESU 2C-1	110	110	0	800	400	0	
ESU 2B	110	110	29	0	N/A	0	
ESU 2A-1	90	90	0	370	185	0	
ESU 4A	135	135	40	0	N/A	0	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: B-2, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
71	ESU 1A	1	0.38

Shotcrete facing data design section Design Section 1 - 15' M-P Sta. 0+17.5 to 0+52.5



Temporary stage facing thickness (cBot x 2) = 4in
Concrete strength Fc'= 4ksi
Rebar and mesh yield strength Fy= 60ksi
Back face hor. reinforcement (or mesh) W4.0@4in area a.bh=0.12 in^2/ft
Back face vertical reinforcement (or mesh) W4.0@4in area a.bv=0.12 in^2/ft

Stage	Active	Top El.	Bottom El.	Two stage facing	Thickness
Name	Yes/No	(ft)	(ft)	-	(in)
Install Nail 2	Yes	71	66	Temporary	4
Install Nail 3	Yes	71	61	Temporary	4
Final Ex. Internal	Yes	71	55.5	Temporary	4

Soil nail input data for design section Design Section 1 - 15' M-P Sta. 0+17.5 to 0+52.5

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
N1	3: #7Gr.75	15	0	63.5	32	0	5	0.6	6	75
N2	3: #7Gr.75	15	0	58.5	14	0	5	0.6	6	75
Nail 1	3: #7Gr.75	15	0	68.5	32	0	5	0.6	6	75

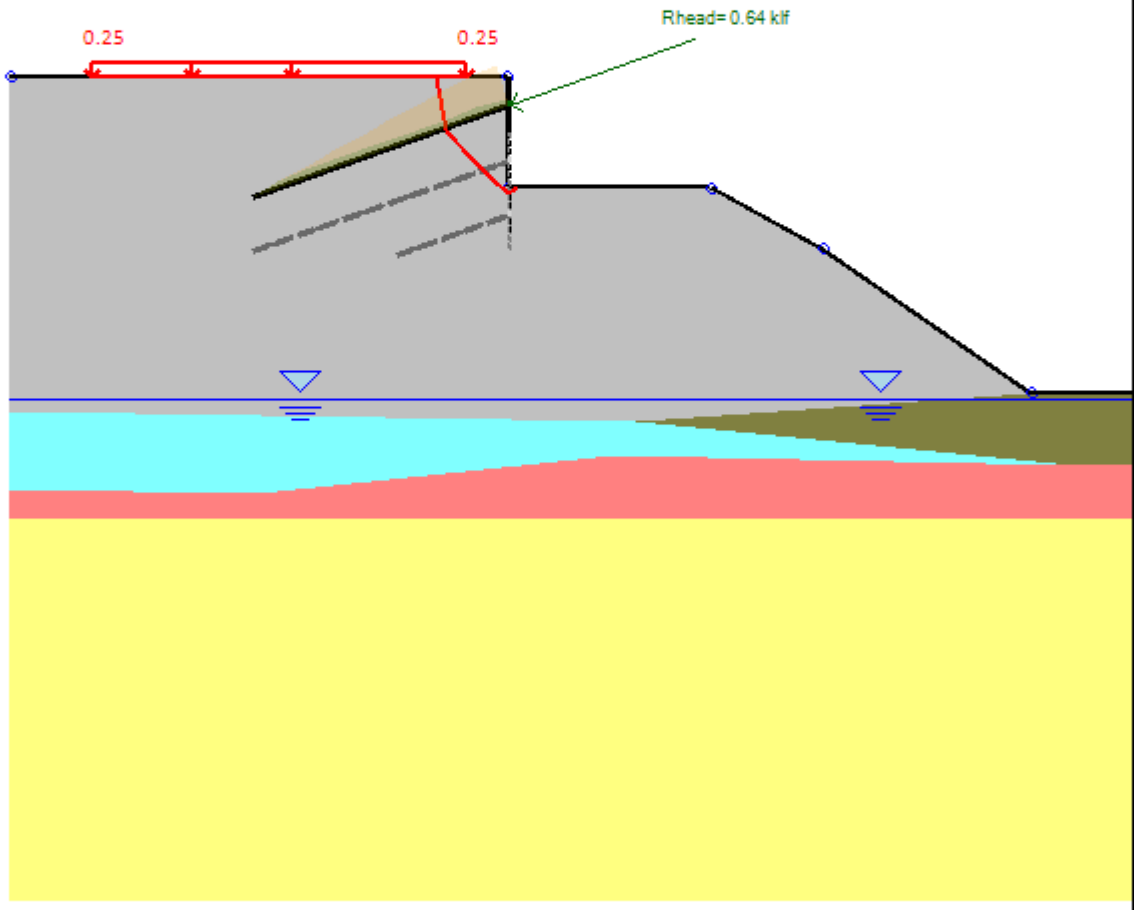
Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
N1	63.5	7	0.75	50	1	N/A	N/A	#4
N2	58.5	7	0.75	50	1	N/A	N/A	#4
Nail 1	68.5	7	0.75	50	1	N/A	N/A	#4

Design Section 1 - 15' M-P Sta. 0+17.5 to 0+52.5

Morgenstern-Price, FSsuggested.min = 1.35
Automatic search(Left exit pt: -8.486ft, 71ft)
(Right exit pt: 1.092ft, 61ft)

FS= 1.387

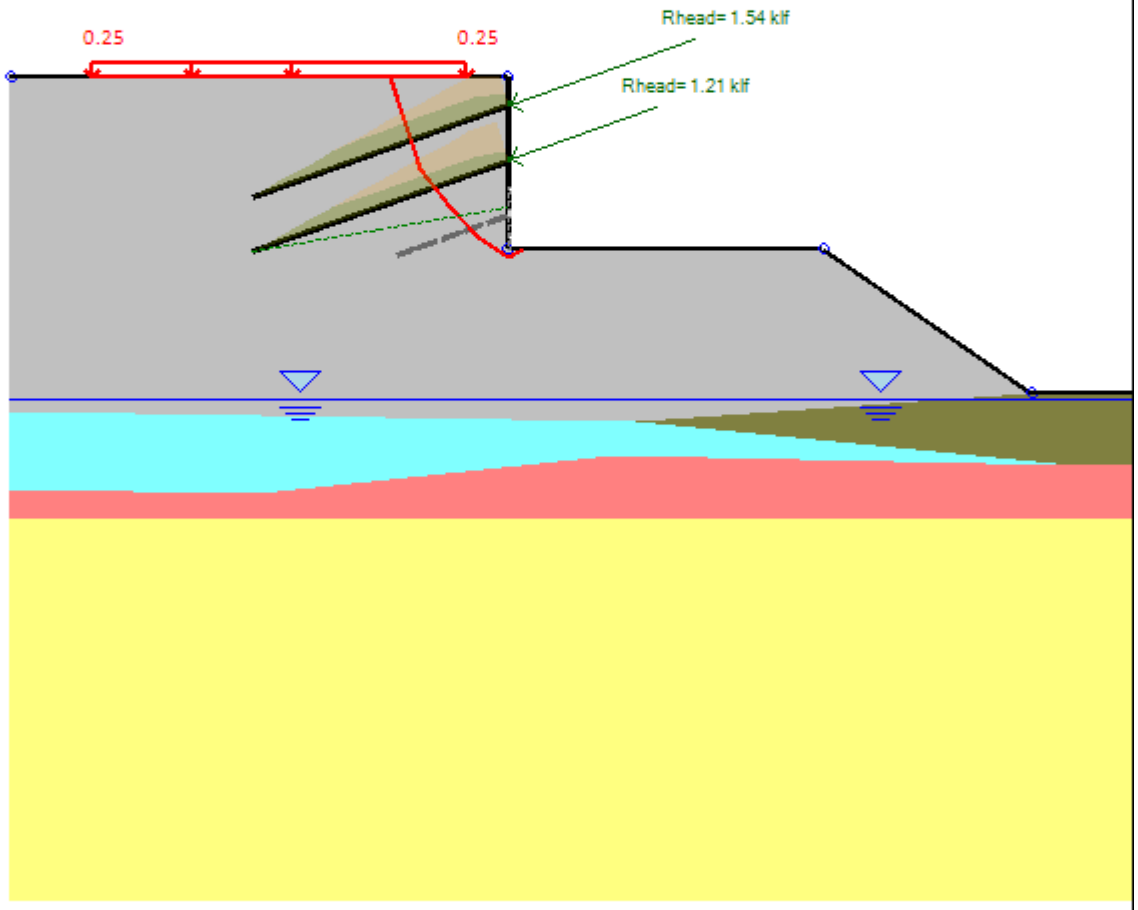


Company: My Company Engineer: Engineer	DS: 0, Install Nail 2	Deep Excavation LCC SnailPlus 2021
C:\Us..eepEx SNAIL Win\Reduced Bond 10-18-21\Wall 7.15 Shoring.SNLP		10/18/2021

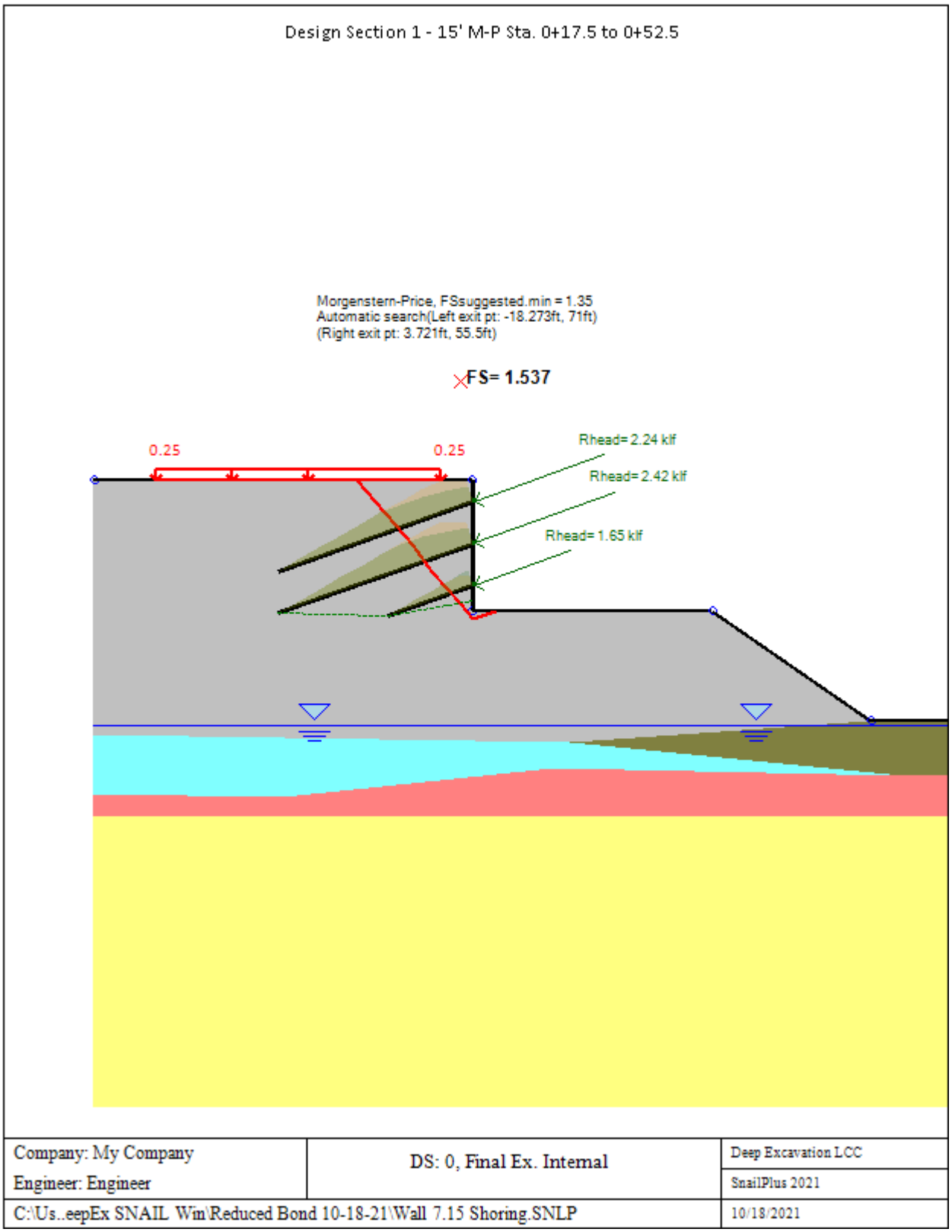
Design Section 1 - 15' M-P Sta. 0+17.5 to 0+52.5

Morgenstern-Price, FSsuggested.min = 1.35
Automatic search(Left exit pt: -14.152ft, 71ft)
(Right exit pt: 1.794ft, 55.5ft)

FS= 1.464



Company: My Company Engineer: Engineer	DS: 0, Install Nail 3	Deep Excavation LCC SnailPlus 2021
C:\Us..eepEx SNAIL Win\Reduced Bond 10-18-21\Wall 7.15 Shoring.SNLP		10/18/2021



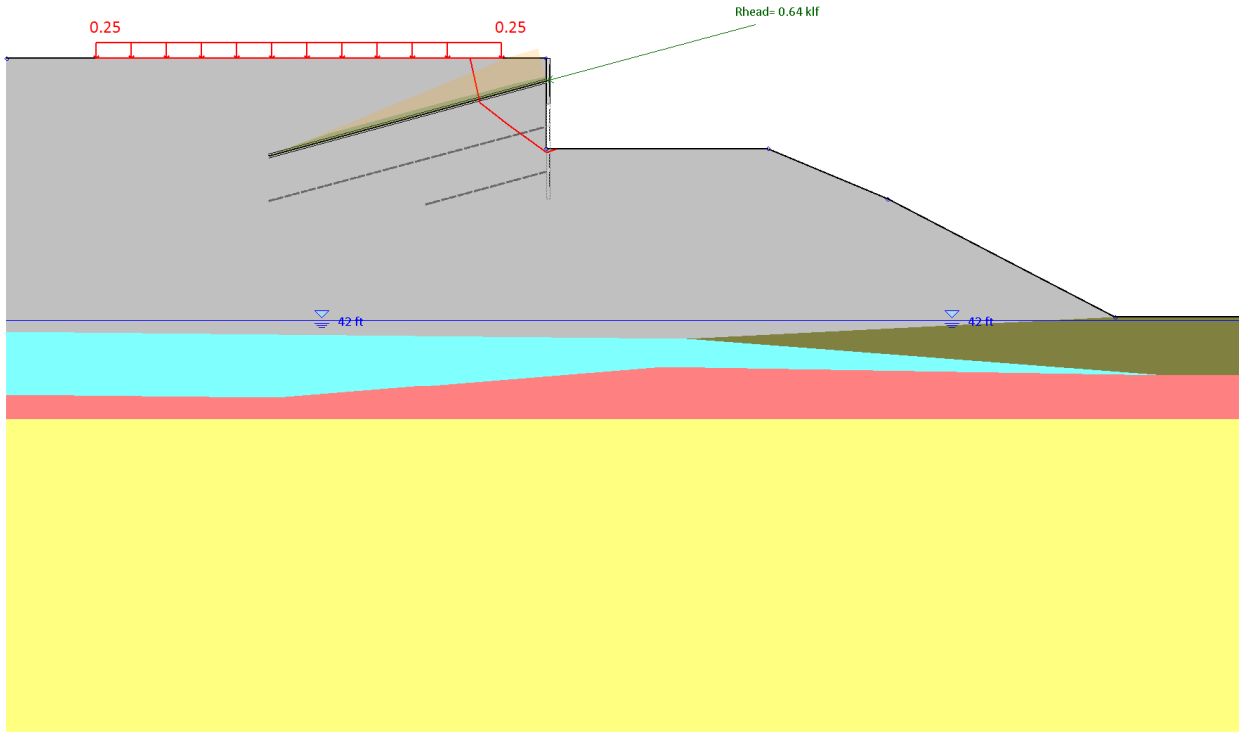
Quick analysis summary for design section: Design Section 1 - 15' M-P Sta. 0+17.

Design Section 1 - 15' M-P Sta. 0+17.5 to 0+52.5

ESU 4A (UND.)	135	0	-	40	0

Morgenstern-Price, FSsuggested.min = 1.35
Automatic search(Left exit pt: -8.486ft, 71ft)
(Right exit pt: 1.092ft, 61ft)

FS= 1.387



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.387	4.57	3.22	0.183	0.199	0.127	Yes	Yes
Install Nail 3	Calculated	1.464	10.96	7.72	0.438	0.477	0.304	Yes	Yes
Final Ex. Intern	Calculated	1.537	17.19	12.12	0.988	0.748	0.477	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.387	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Install Nail 3	Yes	1.464	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	1.537	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	25	0.183	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 3)	N/A		Service Facto	24.9	0.438	N/A	N/A	N/A
xL (-57 to -7.	xR (0.01 to 1	N/A		Service Facto	23.3	0.988	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term
Min required FS	1.35
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Automatic
Left limits	-57ft to -7.125ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N1	3: #7Gr.75	15	0	63.5	32	0	5	2.4235	12.12
N2	3: #7Gr.75	15	0	58.5	14	0	5	1.653	8.27
Nail 1	3: #7Gr.75	15	0	68.5	32	0	5	2.2385	11.19

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	55.5
4	37.9	55.5
5	63.1	42.4
6	80	42.4

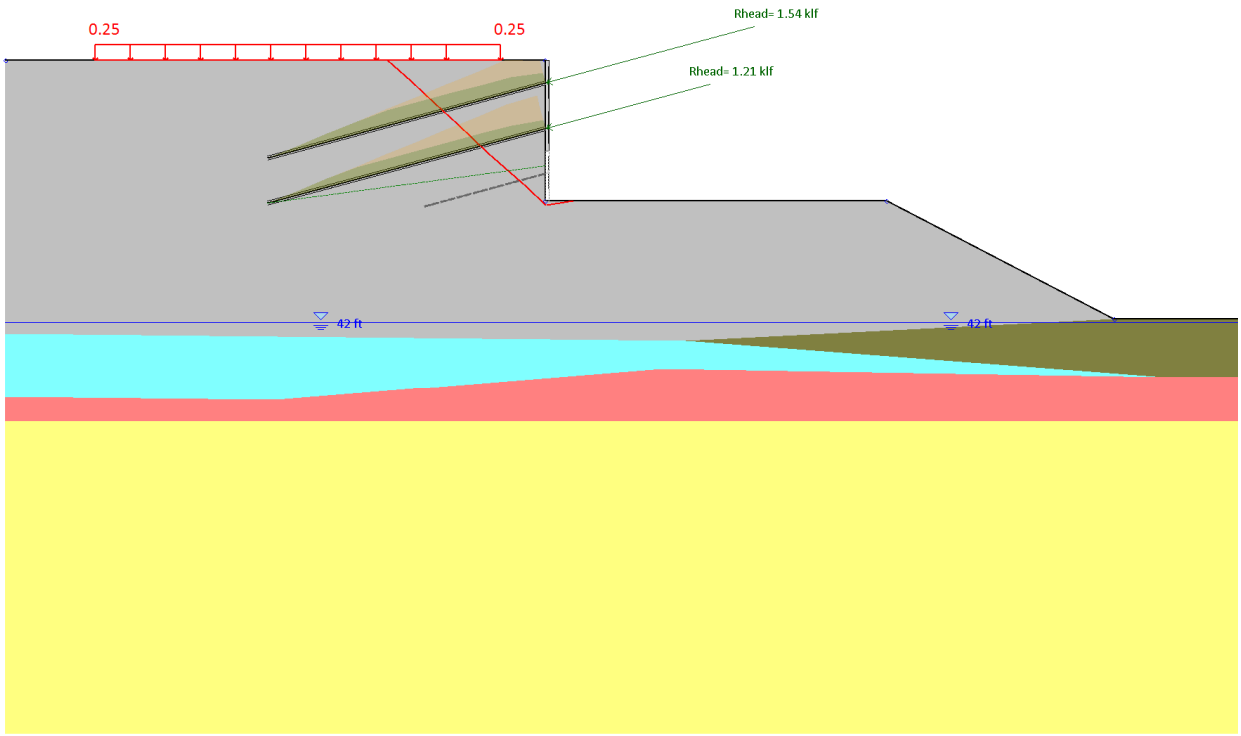
Quick analysis summary for design section: Design Section 1 - 15' Spencer Sta. 0

Design Section 1 - 15' Spencer Sta. 0+17.5 to 0+52.5

ESU 4A (DR.)	135	0	-	40	0

Spencer, FSsuggested.min = 1.35
Automatic search(Left exit pt: -17.547ft, 71ft)
(Right exit pt: 2.994ft, 55.5ft)

FS= 1.393



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.53	4.57	3.22	0.183	0.199	0.127	Yes	Yes
Install Nail 3	Calculated	1.393	10.96	7.72	0.438	0.477	0.304	Yes	Yes
Final Ex. Intern	Calculated	1.546	17.19	12.12	0.988	0.748	0.477	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.53	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Install Nail 3	Yes	1.393	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	1.546	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	25	0.183	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 3)	N/A		Service Facto	24.9	0.438	N/A	N/A	N/A
xL (-57 to -7.	xR (0.01 to 1	N/A		Service Facto	23.3	0.988	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term
Min required FS	1.35
Method	Spencer
Nail methods	Available shear
Surface search	Automatic
Left limits	-57ft to -7.125ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	3: #7Gr.75	15	0	68.5	32	0	5	2.2385	11.19
N1	3: #7Gr.75	15	0	63.5	32	0	5	2.4235	12.12
N2	3: #7Gr.75	15	0	58.5	14	0	5	1.653	8.27

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	55.5
4	37.9	55.5
5	63.1	42.4
6	80	42.4

Soil type property data

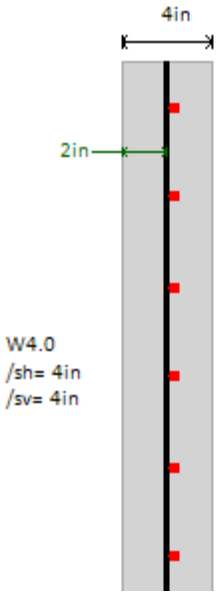
Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1A	115	115	34	0	N/A	7.5	
ESU 2C-1	110	110	0	800	400	0	
ESU 2B	110	110	29	0	N/A	0	
ESU 2A-1	90	90	0	370	185	0	
ESU 4A	135	135	40	0	N/A	0	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: B-2, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
71	ESU 1A	1	0.38

Shotcrete facing data design section Design Section 1 - 15' Spencer Sta. 0+17.5 to 0+52.5



Temporary stage facing thickness (cBot x 2) = 4in
Concrete strength Fc'= 4ksi
Rebar and mesh yield strength Fy= 60ksi
Back face hor. reinforcement (or mesh) W4.0@4in area a.bh=0.12 in^2/ft
Back face vertical reinforcement (or mesh) W4.0@4in area a.bv=0.12 in^2/ft

Stage	Active	Top El.	Bottom El.	Two stage facing	Thickness
Name	Yes/No	(ft)	(ft)	-	(in)
Install Nail 2	Yes	71	66	Temporary	4
Install Nail 3	Yes	71	61	Temporary	4
Final Ex. Internal	Yes	71	55.5	Temporary	4

Soil nail input data for design section Design Section 1 - 15' Spencer Sta. 0+17.5 to 0+52.5

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
N0	3: #7Gr.75	15	0	68.5	32	0	5	0.6	6	75
N1	3: #7Gr.75	15	0	63.5	32	0	5	0.6	6	75
N2	3: #7Gr.75	15	0	58.5	14	0	5	0.6	6	75

Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
N0	68.5	7	0.75	50	1	N/A	N/A	#4
N1	63.5	7	0.75	50	1	N/A	N/A	#4
N2	58.5	7	0.75	50	1	N/A	N/A	#4

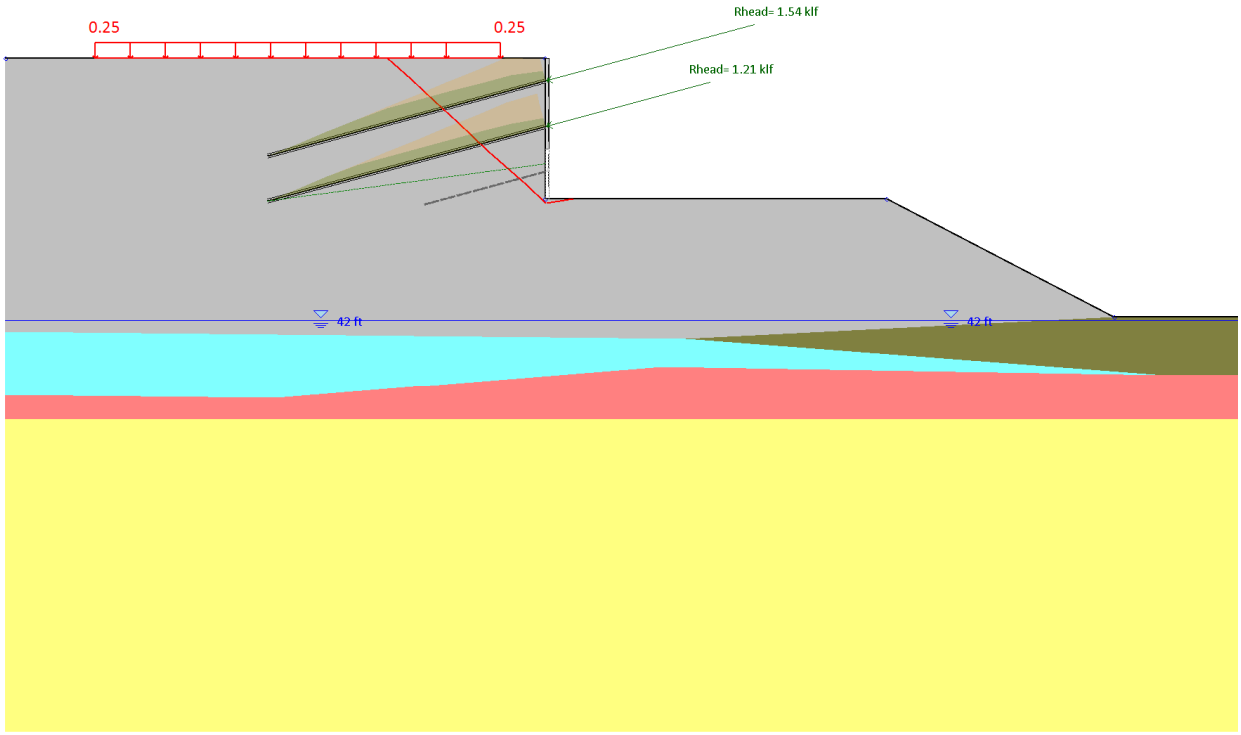
Quick analysis summary for design section: Design Section 1 - 15' Spencer Sta. 0

Design Section 1 - 15' Spencer Sta. 0+17.5 to 0+52.5

ESU 4A (DR.)	135	0	-	40	0

Spencer, FSsuggested.min = 1.35
Automatic search(Left exit pt: -17.547ft, 71ft)
(Right exit pt: 2.994ft, 55.5ft)

FS= 1.393



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.53	4.57	3.22	0.183	0.199	0.127	Yes	Yes
Install Nail 3	Calculated	1.393	10.96	7.72	0.438	0.477	0.304	Yes	Yes
Final Ex. Intern	Calculated	1.546	17.19	12.12	0.988	0.748	0.477	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.53	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Install Nail 3	Yes	1.393	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	1.546	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	25	0.183	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 3)	N/A		Service Facto	24.9	0.438	N/A	N/A	N/A
xL (-57 to -7.	xR (0.01 to 1	N/A		Service Facto	23.3	0.988	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term
Min required FS	1.35
Method	Spencer
Nail methods	Available shear
Surface search	Automatic
Left limits	-57ft to -7.125ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	3: #7Gr.75	15	0	68.5	32	0	5	2.2385	11.19
N1	3: #7Gr.75	15	0	63.5	32	0	5	2.4235	12.12
N2	3: #7Gr.75	15	0	58.5	14	0	5	1.653	8.27

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	55.5
4	37.9	55.5
5	63.1	42.4
6	80	42.4

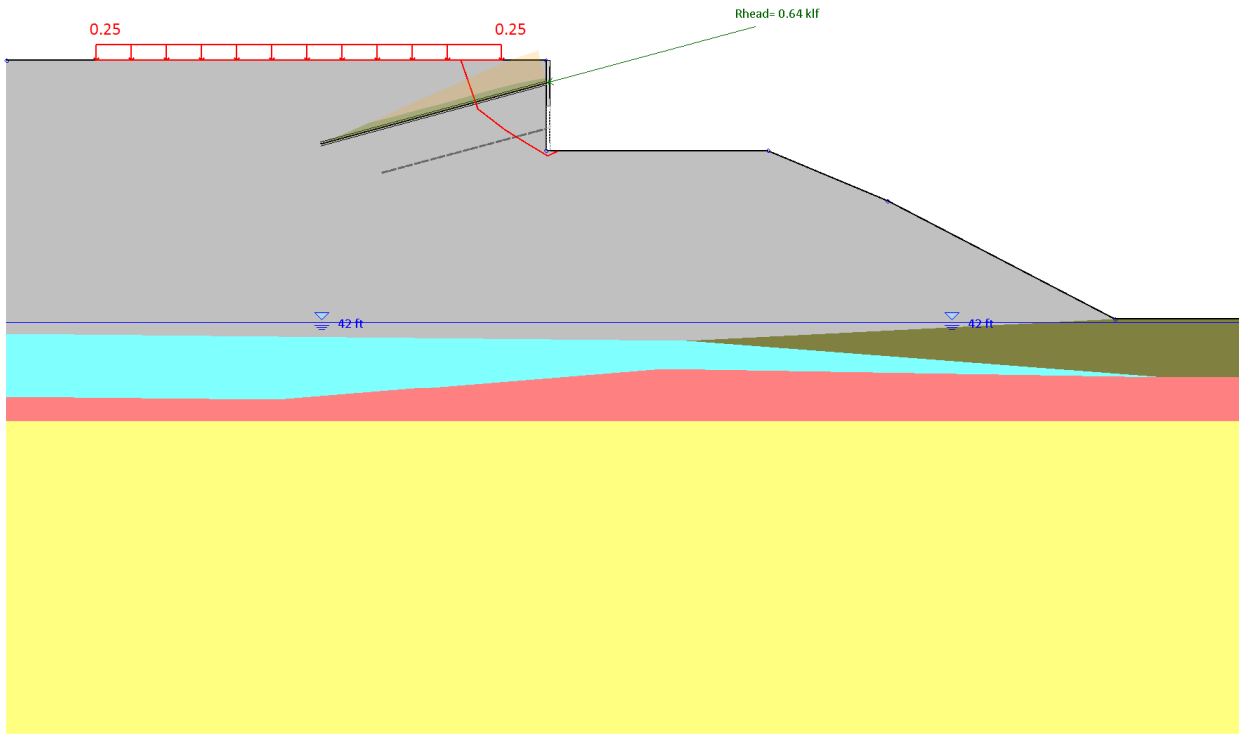
Quick analysis summary for design section: Design Section 2 - 10' M-P Sta. 0+00

Design Section 2 - 10' M-P Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23

ESU 4A (DR.)	135	0	-	40	0

Morgenstern-Price, FSsuggested.min = 1.35
Automatic search(Left exit pt: -9.525ft, 71ft)
(Right exit pt: 1.243ft, 61ft)

FS= 1.361



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.361	4.57	3.22	0.207	0.199	0.127	Yes	Yes
Final Ex. Intern	Calculated	1.837	10.96	7.72	0.533	0.477	0.304	Yes	Yes
Final Cut Belo	Calculated	1.42	10.96	7.72	0.533	0.477	0.304	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.361	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	1.837	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Cut Bel	Yes	1.42	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 2)	N/A		Service Facto	20.61	0.207	N/A	N/A	N/A
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	20.61	0.533	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 1	N/A		Service Facto	19.22	0.533	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term 48hrs
Min required FS	1.35
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Automatic
Left limits	-30ft to -3.75ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	3: #7Gr.75	15	0	68.5	26	0	5	1.5443	7.72
N1	3: #7Gr.75	15	0	63.5	19	0	5	1.2114	6.06

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	61
4	8.25	55.5
5	37.9	55.5
6	63.1	42.4
7	80	42.4

Soil type property data

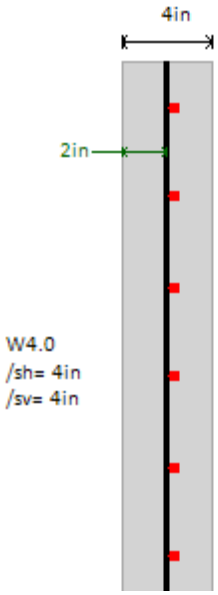
Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1A	115	115	34	0	N/A	7.5	
ESU 2C-1	110	110	0	800	400	0	
ESU 2B	110	110	29	0	N/A	0	
ESU 2A-1	90	90	0	370	185	0	
ESU 4A	135	135	40	0	N/A	0	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: B-2, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
71	ESU 1A	1	0.38

Shotcrete facing data design section Design Section 2 - 10' M-P Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23



Temporary stage facing thickness (cBot x 2) = 4in
Concrete strength Fc'= 4ksi
Rebar and mesh yield strength Fy= 60ksi
Back face hor. reinforcement (or mesh) W4.0@4in area a.bh=0.12 in^2/ft
Back face vertical reinforcement (or mesh) W4.0@4in area a.bv=0.12 in^2/ft

Stage	Active	Top El.	Bottom El.	Two stage facing	Thickness
Name	Yes/No	(ft)	(ft)	-	(in)
Install Nail 2	Yes	71	66	Temporary	4
Final Ex. Internal	Yes	71	61	Temporary	4
Final Cut Below	Yes	71	61	Temporary	4

Soil nail input data for design section Design Section 2 - 10' M-P Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
N0	3: #7Gr.75	15	0	68.5	26	0	5	0.6	6	75
N1	3: #7Gr.75	15	0	63.5	19	0	5	0.6	6	75

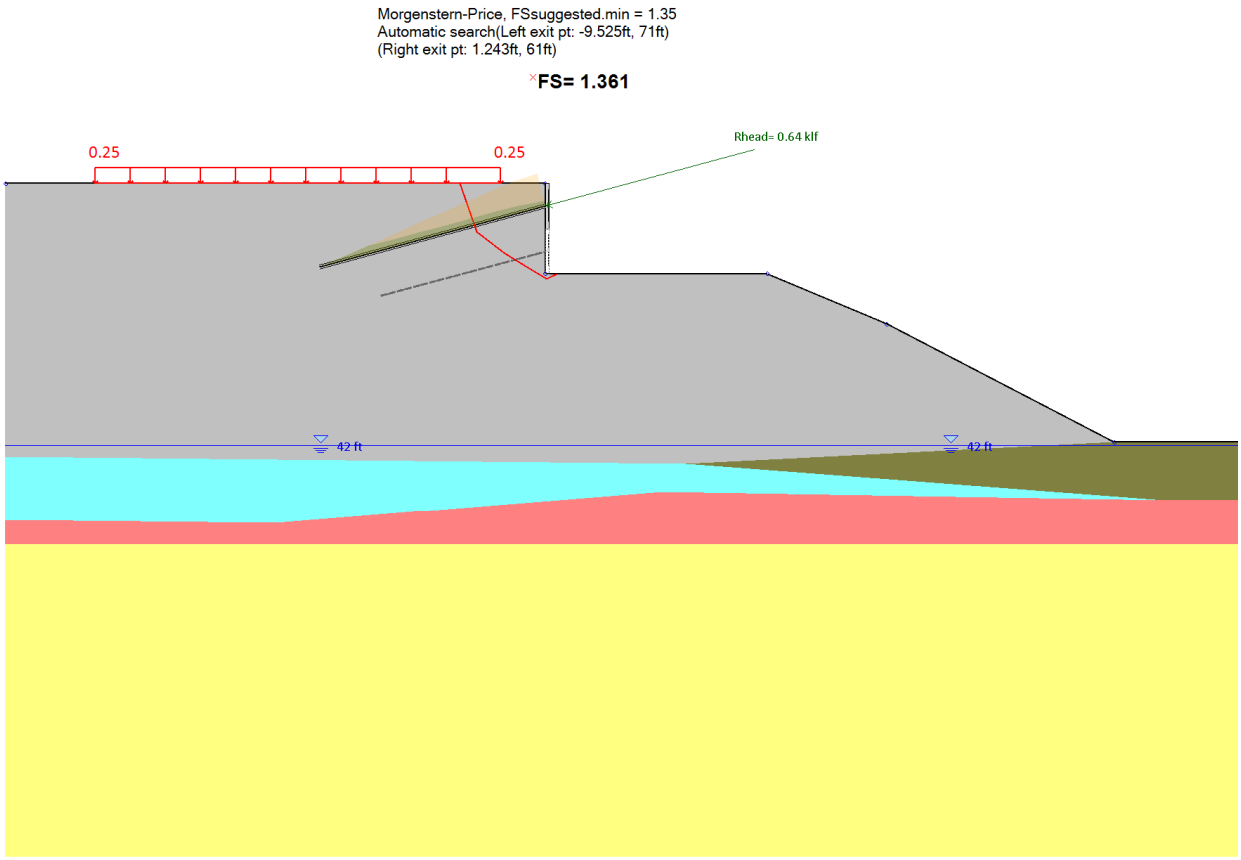
Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
N0	68.5	7	0.75	50	1	N/A	N/A	#4
N1	63.5	7	0.75	50	1	N/A	N/A	#4

Quick analysis summary for design section: Design Section 2 - 10' M-P Sta. 0+00

Design Section 2 - 10' M-P Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23

ESU 4A (DR.)	135	0	-	40	0



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.361	4.57	3.22	0.207	0.199	0.127	Yes	Yes
Final Ex. Intern	Calculated	1.837	10.96	7.72	0.533	0.477	0.304	Yes	Yes
Final Cut Belo	Calculated	1.42	10.96	7.72	0.533	0.477	0.304	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.361	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	1.837	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Cut Bel	Yes	1.42	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 2)	N/A		Service Facto	20.61	0.207	N/A	N/A	N/A
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	20.61	0.533	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 1	N/A		Service Facto	19.22	0.533	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term 48hrs
Min required FS	1.35
Method	Morgenstern-Price
Nail methods	Available shear
Surface search	Automatic
Left limits	-30ft to -3.75ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Force Tolerance	10%
Initial FS0	1
MP interslice factor m	1
MP interslice factor v	1
MP initial Lamda.0	0
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	3: #7Gr.75	15	0	68.5	26	0	5	1.5443	7.72
N1	3: #7Gr.75	15	0	63.5	19	0	5	1.2114	6.06

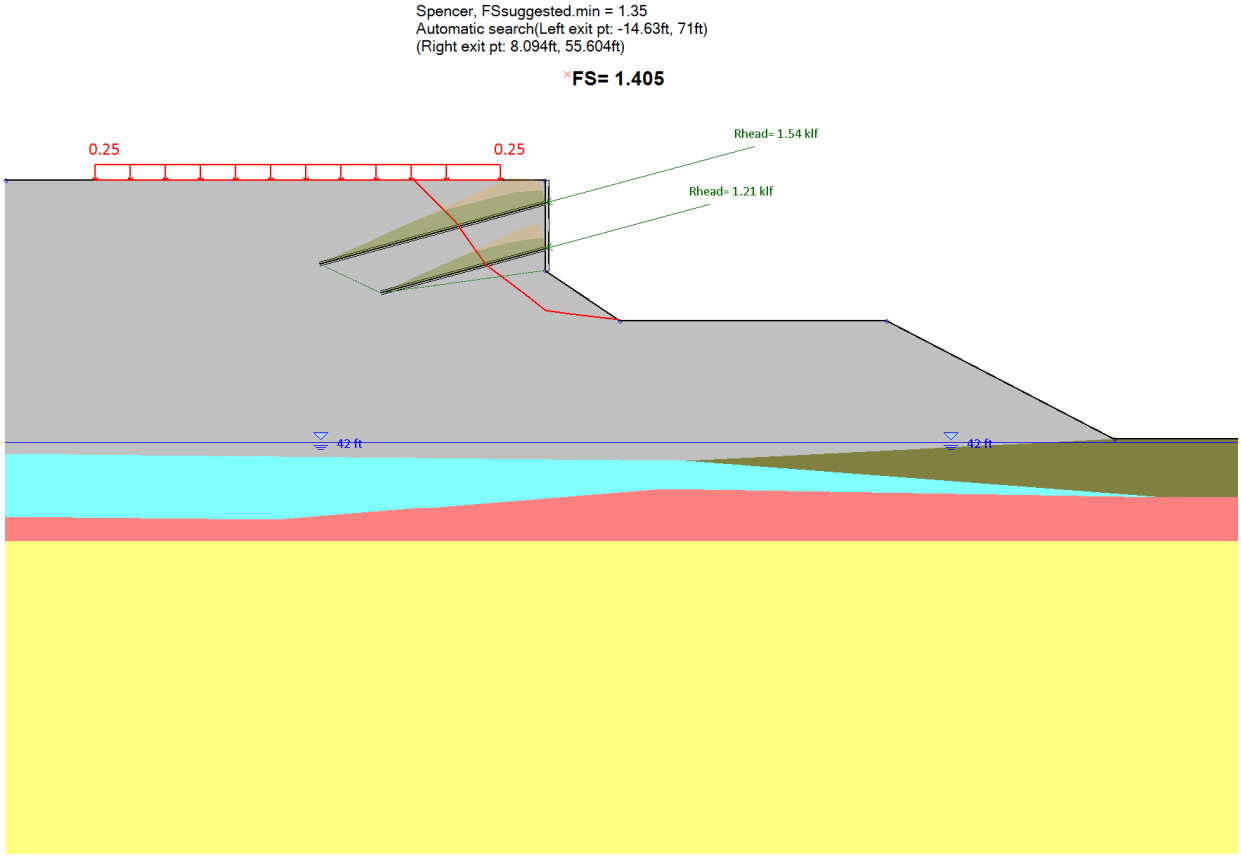
Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	61
4	8.25	55.5
5	37.9	55.5
6	63.1	42.4
7	80	42.4

Quick analysis summary for design section: Design Section 2 -10' Spencer Sta. 0

Design Section 2 -10' Spencer Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23

ESU 4A (UND.)	135	0	-	40	0



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.564	4.57	3.22	0.207	0.199	0.127	Yes	Yes
Final Ex. Intern	Calculated	2.029	10.96	7.72	0.533	0.477	0.304	Yes	Yes
Final Cut Belo	Calculated	1.405	10.96	7.72	0.533	0.477	0.304	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.564	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	2.029	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Cut Bel	Yes	1.405	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	20.61	0.207	N/A	N/A	N/A
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	20.61	0.533	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 1	N/A		Service Facto	19.22	0.533	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term 48hrs
Min required FS	1.35
Method	Spencer
Nail methods	Available shear
Surface search	Automatic
Left limits	-30ft to -3.75ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	3: #7Gr.75	15	0	68.5	26	0	5	1.5443	7.72
N1	3: #7Gr.75	15	0	63.5	19	0	5	1.2114	6.06

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	61
4	8.25	55.5
5	37.9	55.5
6	63.1	42.4
7	80	42.4

Soil type property data

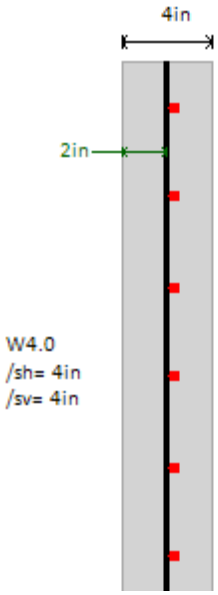
Name	γtot	γdry	Φ'	c'	Su	qBond	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(psi)	
ESU 1A	115	115	34	0	N/A	7.5	
ESU 2C-1	110	110	0	800	400	0	
ESU 2B	110	110	29	0	N/A	0	
ESU 2A-1	90	90	0	370	185	0	
ESU 4A	135	135	40	0	N/A	0	

γtot = Total unit weight below water table
γdry = Bulk unit weight above water table
c' = Effective cohesion (in drained state for clays)
Φ' = Effective friction (in drained state for clays)
Su = Undrained shear strength (for clays in undrained condition)
qBond = Ultimate bond resistance for soil nails

Name: B-2, pos: (50, 0)

Top elev.	Soil type	OCR	Ko
71	ESU 1A	1	0.38

Shotcrete facing data design section Design Section 2 -10' Spencer Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23



Temporary stage facing thickness (cBot x 2) = 4in
Concrete strength Fc'= 4ksi
Rebar and mesh yield strength Fy= 60ksi
Back face hor. reinforcement (or mesh) W4.0@4in area a.bh=0.12 in^2/ft
Back face vertical reinforcement (or mesh) W4.0@4in area a.bv=0.12 in^2/ft

Stage	Active	Top El.	Bottom El.	Two stage facing	Thickness
Name	Yes/No	(ft)	(ft)	-	(in)
Install Nail 2	Yes	71	66	Temporary	4
Final Ex. Internal	Yes	71	61	Temporary	4
Final Cut Below	Yes	71	55.5	Temporary	4

Soil nail input data for design section Design Section 2 -10' Spencer Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23

Name	Nail	α	x	El.	Lfix	Lfree	Space	Asteel	Dfix	Fy
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(in^2)	(in)	(ksi)
N0	3: #7Gr.75	15	0	68.5	26	0	5	0.6	6	75
N1	3: #7Gr.75	15	0	63.5	19	0	5	0.6	6	75

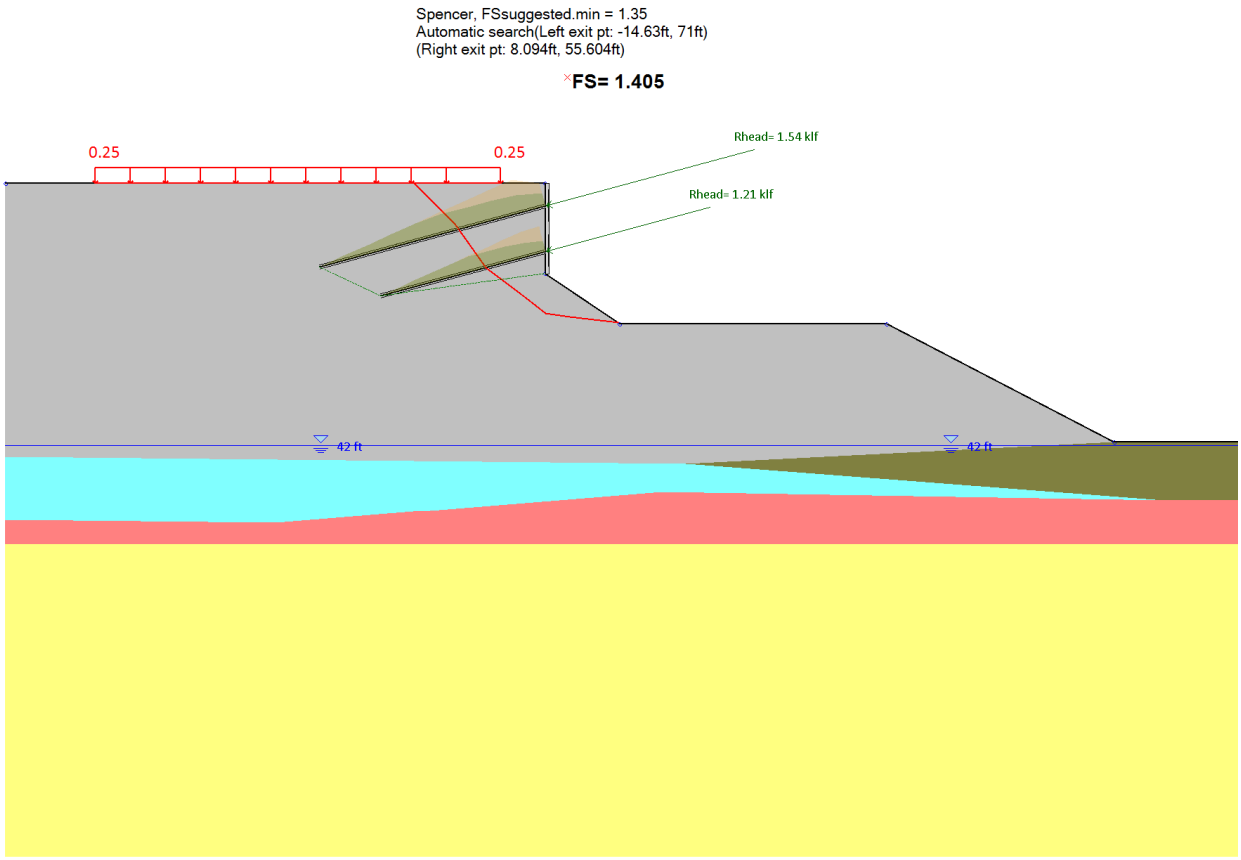
Header plate data

Nail	El.	Width	Thick	Fy	D open.	Studs	c studs	Waler
Number	(ft)	(in)	(in)	(ksi)	(in)	Studs	c studs	Bars
N0	68.5	7	0.75	50	1	N/A	N/A	#4
N1	63.5	7	0.75	50	1	N/A	N/A	#4

Quick analysis summary for design section: Design Section 2 -10' Spencer Sta. 0

Design Section 2 -10' Spencer Sta. 0+00 to 0+17.5 and 0+52.5 to 0+66.23

ESU 4A (UND.)	135	0	-	40	0



Stage	Calculation	FS Slope	Fmax Nails (k)	Fmax Nail@Head (k)	STR Nails	STR Plates	STR Facing	Max. reinf.	Min. reinf.
Install Nail 2	Calculated	1.564	4.57	3.22	0.207	0.199	0.127	Yes	Yes
Final Ex. Intern	Calculated	2.029	10.96	7.72	0.533	0.477	0.304	Yes	Yes
Final Cut Belo	Calculated	1.405	10.96	7.72	0.533	0.477	0.304	Yes	Yes

Fmax Nails = Maximum axial nail force in analysis.
Fmax Nail@head = Maximum axial nail force at facing.
STR Nails= Stress check for nails, Design load/Design Capacity (maintain below 1 for good design).
STR Plates= Stress check for nail plates (punching and bending).
STR Facing= Stress check for facing, Design load/Design Capacity.

Table: Analysis summary for all stages, Part 1

Stage	Analyzed	FS min	FS req. code	Type	Xc (ft)	Zc (ft)	R (ft)	Active (deg)	Passive (deg)
Install Nail 2	Yes	1.564	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Ex. Inte	Yes	2.029	1.35	Automatic	Auto	Auto	N/A	N/A	N/A
Final Cut Bel	Yes	1.405	1.35	Automatic	Auto	Auto	N/A	N/A	N/A

Table: Analysis summary for all stages, Part 2

Point 1	Point 2	Crack (ft)	Design Appro	Design Case	Nail force (k)	Nail check	Support Mre	Wall Mres(k-	MEQ seismic(
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	20.61	0.207	N/A	N/A	N/A
xL (-20 to -2.	xR (0.01 to 3)	N/A		Service Facto	20.61	0.533	N/A	N/A	N/A
xL (-30 to -3.	xR (0.01 to 1	N/A		Service Facto	19.22	0.533	N/A	N/A	N/A

Table: Basic analysis assumptions last stage

Stage conditions	Short term 48hrs
Min required FS	1.35
Method	Spencer
Nail methods	Available shear
Surface search	Automatic
Left limits	-30ft to -3.75ft
Right limits	0.01ft to 15ft
Number of points	5
Min. slice width	3ft
Tolerance	1%
Soil nail analysis	Same settings on all nails
Nail stability	External-Internal
Nail shear	Ignored
FS on nail STR strength	1.8
FS on nail pullout	2
FS on facing bending	1.35
FS on facing punching	1.35
FS on bolts	1.5
FS on bearing	2.5

Table: Nails & max mobilized head forces

Name	Nail	α	x	El.	Lfix	Lfree	Space	Fhead	Fhead
-	Section	deg	(ft)	(ft)	(ft)	(ft)	(ft)	(k/ft)	(k)
N0	3: #7Gr.75	15	0	68.5	26	0	5	1.5443	7.72
N1	3: #7Gr.75	15	0	63.5	19	0	5	1.2114	6.06

Table: Surface point coordinates for last stage

Point	x (ft)	El. (ft)
1	-60	71
2	0	71
3	0	61
4	8.25	55.5
5	37.9	55.5
6	63.1	42.4
7	80	42.4

Appendix C – Atlas Geotechnical -Geotech Doc for Final Review Rev 1

Geotechnical Documentation for Final Design – Rev. 2

RW 07.15R Temporary Soil Nail Wall

I-405; Renton to Bellevue Widening and Express Toll Lanes Project
Renton, Washington

Prepared for:

Drill Tech Drilling & Shoring, Inc.

2200 Wymore Way
Antioch, CA 94509

This work was prepared by me or under my supervision.

Douglas R. Schwarm, PE
Exp. 29 October 2023

Rev. No.	Date	Description
A	25 March 2021	DTDS Review
0	16 July 2021	Construction
1	30 August 2021	Construction
2	09 December 2021	Construction

Memorandum

Project: RW 07.15R Temporary Soil Nail Wall

Subject: Geotechnical Documentation for Final Design – Rev. 2

Date: 9 December 2021

This memo supersedes and replaces memos 30 August 21 Geotechnical Documentation and 18 October Developed Bond Strength. This memo also includes data from a recent additional boring drilled by Terracon for FLJV.

Geotechnical Design Parameters

Table 1 summarizes the geotechnical parameters for designing the RW 07.15R Temporary Soil Nail Wall (TSNW), which shores a temporary excavation into the I-405 embankment so earthwork and drilling equipment can access the permanent RW 07.15R foundation. The TSNW is 67 feet long and up to 15.5 feet high.

Table 1 – Geotechnical parameters for TSNW design.

Soil Type	γ (pcf)	ϕ'	Surcharge (psf)	GWT Elev. (ft)	Soil/Grout Bond Strength (Ultimate) (psi)
SM	115	34°	250	42	7.5

The remainder of this memo provides geotechnical documentation for final design according to Section 23.4.2 of the Geotechnical Design Manual (GDM). This geotechnical documentation memo is part of a computations package that includes drawings showing:

- A plan of the existing and planned ground lines, the TSNW alignment, and the borehole locations,
- The TSNW in elevation with boring logs and idealized section, including soil description and properties used for design.
- Sections through the TSNW also showing the boring logs, interpreted section, and design parameters. The critical design section, with engineering parameters noted, appear in the Global Stability computations as well as the construction drawings.

Geotechnical Documentation

Borehole Data Density

Subsurface data is available from Wood's 30 September 2020 RW 07.15R Geotechnical Engineering Report, which incorporates data from prior investigations. Also, on 29 November 2021 Terracon drilled a borehole for FLJV (B-1-2021 log in Appendix D) in the bond zone

behind TSNW 07.15 to satisfy a contract requirement. Figure 1 shows the borehole locations near the TSNW face and in the bond zone.

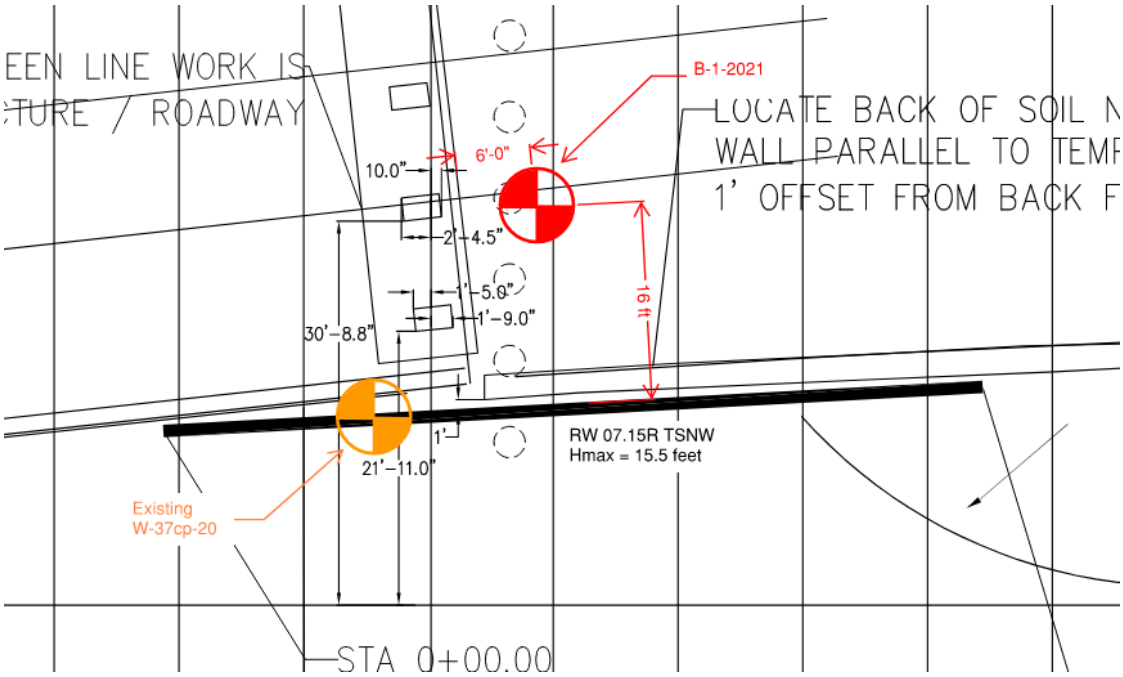


Figure 1 – Borings W-37cp-20 and B-1-2021 relative to the TSNW.

For soil nail walls less than 100 feet long, the GDM requires one geotechnical exploration along the alignment (15-3.4.1) and another in the nail zone behind the wall (15-3.4.2.1). The two boreholes shown in Figure 1 satisfy that requirement.

Soil Stratigraphy

Borings R2B-22vw-17, W-37cp-20, and B-1-2021 show that the TSNW will retain only ESU 1A, loose to medium dense silty sand embankment fill, USCS designation SM. Average SPT blow counts from the face and bond zone boring logs indicate that ESU 1A is slightly denser than at the other boring locations used to characterize ESU 1A at RW 07.15R. There are no notable "soft" spots with excessive fines and/or low SPT blow counts, with the lowest value being 7 blows/ft at a depth close to Row 1 nail elevations. The recent borehole was characterized using the approved geotechnical soil properties methodology. Including the recent borehole in the ESU 1A soil properties slightly increased average SPT blow counts by about 15% and average WSDOT correlated friction angle by about 2.5%, and the statistical variance for both properties was about 20% lower. For consistency with other designs at this site, the mean minus one standard deviation strength value from the RFU Geotechnical Report is adequate for characterizing ESU 1A behind the TSNW.

Groundwater

The RFU 07.15R Geotechnical Report established a maximum water level of 42 feet at boring R2B-22vw-17. Permanent works at this site design for elevation 40 feet, more than 15 feet

deeper than the bottom of the TSNW. Groundwater is not a significant design concern for the TSNW.

Soil Properties Basis

GDM 15-7.6.2.6 (Jan. 2019) requires the following geotechnical information for soil nail walls:

1. Soil stratigraphy
2. Unit weight
3. Shear strength
4. Surcharge loading
5. Foreslope inclination
6. Backslope inclination
7. Groundwater conditions

Table 2 summarizes these required parameters averaged over the depth interval that the TSNW will interact with the soil. These values are consistent with those provided in Table 6 of the RFU Geotechnical Report.

Table 2 – Engineering soil parameters for embankment fill.

Soil Type	γ (pcf)	$\phi'_{lower,GDM}$	Surcharge (psf)	Foreslope inclination	Backslope Inclination (deg)	GWT Elev. (ft)
SM	115	34°	250	1.5H:1V	0	42

Though not listed in the GDM design input requirements, soil nail bond capacity on the grout/soil interface is an important design parameter. Nails are designed using an ultimate failure capacity of 1.7 kips/ft of nail. This value assumes 6-inch diameter holes, rotary (air) drilling, gravity grouting, and a 7.5-psi bond strength on the soil/grout interface. The selected ultimate bond strength is governed by verification test results, as described in a following section of this memo, consistent with design guidance from Table 4.4a in GEC 7 (FHWA-NHI-14-007, Feb. 2015).

Design Methods

The temporary soil nail wall has been designed using the methods and requirements contained in:

1. WSDOT Geotechnical Design Manual (GDM) M 46-03.12, May 2015, amended with Chapters 6 & 15 January 2019.
2. AASHTO LRFD Bridge Design Specifications 9th Edition, 2020, as required by GDM 15-7.3.2 (Jan. 2019).
3. FHWA Soil Nail Walls Reference Manual, FHWA-NHI-14-007, FHWA GEC 007, February 2015.

Figure 1 shows the failure modes for soil nail walls. Internal Stability and Compound Stability failure modes are addressed and summarized in a separate design narrative included in the Drill Tech Drilling & Shoring calculations package. Global Stability failure modes, though, consider slopes related to equipment access explorations and are addressed in this geotechnical computation package.

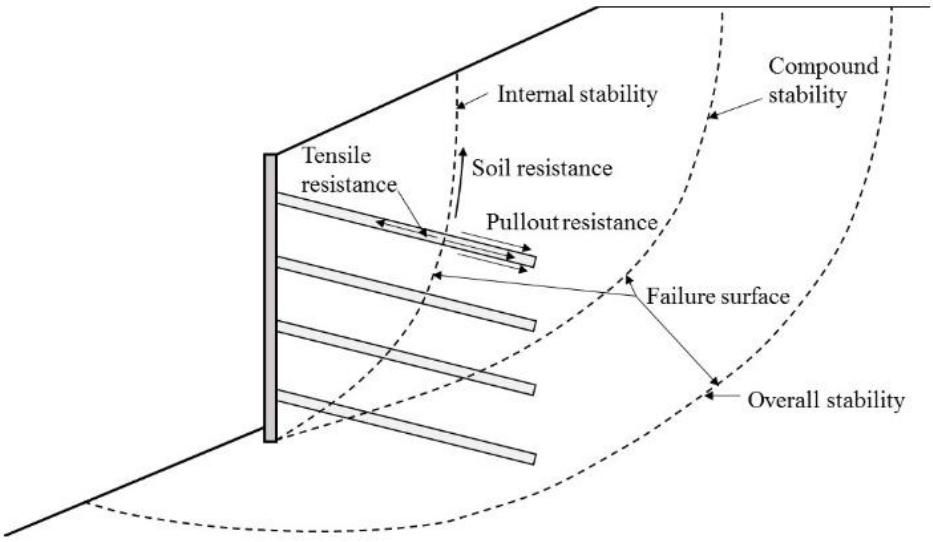


Figure 2 – Failure modes in soil nail walls from Figure C11.12.2-1 of AASHTO LRFD 2020.

Performance Requirements

Tables 3 and 4 show load and resistance factors for global stability analyses of temporary soil nail walls. By using EV=1.0, the 0.75 resistance factor equates to an ASD safety factor of 1.3 for the global and compound stability analysis.

Table 3 – Load factors for Permanent Loads from AASHTO (2020) Table 3.4.1-2.

Case		Load Factor
EV	Vertical Earth Pressure – Internal and compound stability for soil failure in soil nail walls	1.00

Table 4 – Resistance Factors for Soil Nail Walls from AASHTO (2020) Table 11.5.7-1.

Case	Resistance Factor	Factor of Safety
Overall and Compound Stability, soil failure	0.75	1.3

Global Stability

Global stability was analyzed for the critical condition, i.e. the construction stage where the TSNW has been installed and excavation to working grade for wall construction is complete. The analyses consider a section taken at the location of the maximum wall and foreslope height, which occurs at Wall Sta. 0+75 (Section A-A' in the RFU RW 07.15R Geotechnical Report).

The stability analyses indicate a safety factor of 1.40, satisfying the global stability performance requirement. Appendix A includes the global stability runs with the full output file for ease of checking and, if necessary, future duplication.

Soil/Grout Bond Strength

Chapter 15 Section 15-1 of the WSDOT Geotechnical Design Manual refers designers out to the Federal Highway Administration Geotechnical Engineering Circular No. 7, Soil Nail Walls for the design of soil nail walls. FHWA GEC No. 7 offers this guidance for selecting soil nail bond strengths:

> *"For preliminary design, the nominal bond strength of a soil nail can be estimated from published literature, correlations with parameters obtained from field tests, and soil nail load tests. Engineers may also estimate the bond strength based on local experience and construction techniques. The bond strength is not measured in the laboratory because the key aspects affecting the bond strength cannot be easily reproduced. Final design requires verification of the bond strengths with load tests (see Chapter 9).*
>
> *Typical ranges of the bond strength are included in Table 4.4 for gravity grouted soil nails. The bond strengths in Table 4.4 are provided for guidance. It is important that the design engineer estimates bond strengths based on soil descriptions and other factors, such as the soil shear strength and overburden, as described below. It is important that the bond strengths from Table 4.4 or any other source to be used in design must be confirmed in the field by soil nail load testing."*

Verification tests were performed following the FHWA guidance. Four verification nails at the RW 07.15R TSNW site failed to achieve the initially selected 15 lb/in^2 soil/grout bond strength. Table 5 summarizes the test results, and the test reports are shown in Appendix C.

Table 5 - Verification Test Results

Nail No.	Diameter (in)	Length (ft)	Failure Load		Test Date
			Force (kips)	Stress (lb/in^2)	
VN1	6	10	25.5	11.3	11 Oct 2021
VN2	6	10	23.0	10.1	11 Oct 2021
VN2.1	8	10	25.5	8.5	15 Oct 2021
VN2.2	8	10	24.0	8.0	15 Oct 2021

The verification nails achieved between 53% and 75% of the initially anticipated design value. Considering these data, and following the guidance in GEC 7, the soil nails have been reproportioned for a 7.5 lb/in^2 ultimate bond strength.

Existing Structures

Soil nails will be installed close to the existing bridge abutment and some load will be transferred through the soil nails to the abutment. The stability of the abutment was evaluated frictional resistance between the soil and the abutment is about 4 times greater than the load transferred through the soil nails. For more details about the abutment loading analyses, see the 16 July 2021 May Creek Bridge Lateral Stability memorandum (attached in Appendix B).

Summary

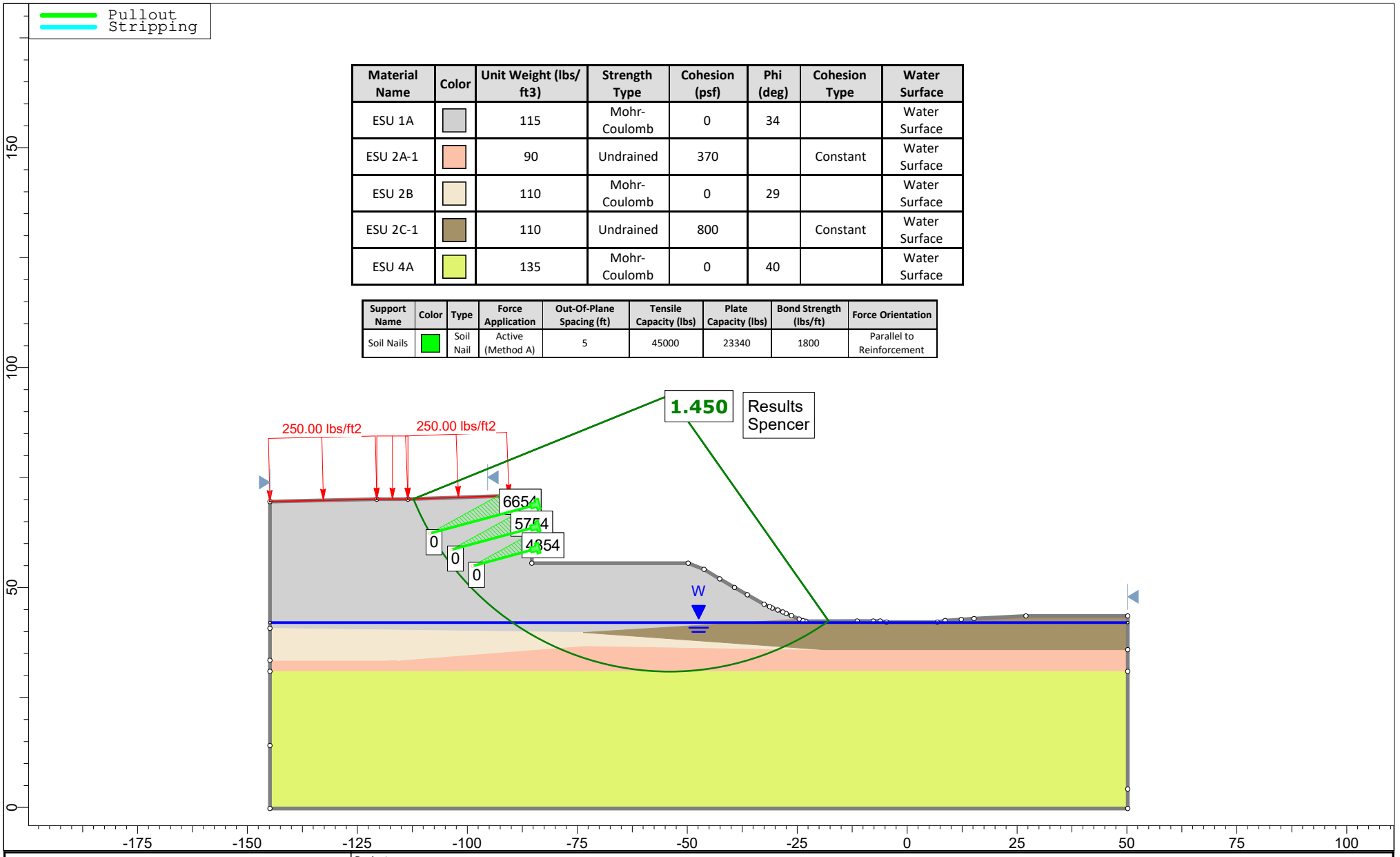
1. The planned RW 07.15R TSNW retains loose to medium dense compacted embankment fill that is more than 13 feet above the design groundwater elevation.
2. The nail arrangement is typical, but the verification tests revealed low soil/grout bond strength, so the nails are long relative to typical temporary soil nail walls in granular fill soils. The accompanying design computations provide additional detail about steel and concrete stresses and other internal stability design considerations.
3. At the critical construction stage, with the site excavated to working grade, but the timber pile ground improvement elements not yet in place, the wall-and-slope configuration has adequate safety against global instability.
4. The soil nail wall should be designed with the 7.5 lb/in^2 ultimate bond strength calculated from the verification tests.

Appendix A – Global Stability Analysis

Pullout
Stripping

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
ESU 1A		115	Mohr-Coulomb	0	34		Water Surface
ESU 2A-1		90	Undrained	370		Constant	Water Surface
ESU 2B		110	Mohr-Coulomb	0	29		Water Surface
ESU 2C-1		110	Undrained	800		Constant	Water Surface
ESU 4A		135	Mohr-Coulomb	0	40		Water Surface

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Bond Strength (lbs/ft)	Force Orientation
Soil Nails		Soil Nail	Active (Method A)	5	45000	23340	1800	Parallel to Reinforcement



ATLAS GEOTECHNICAL

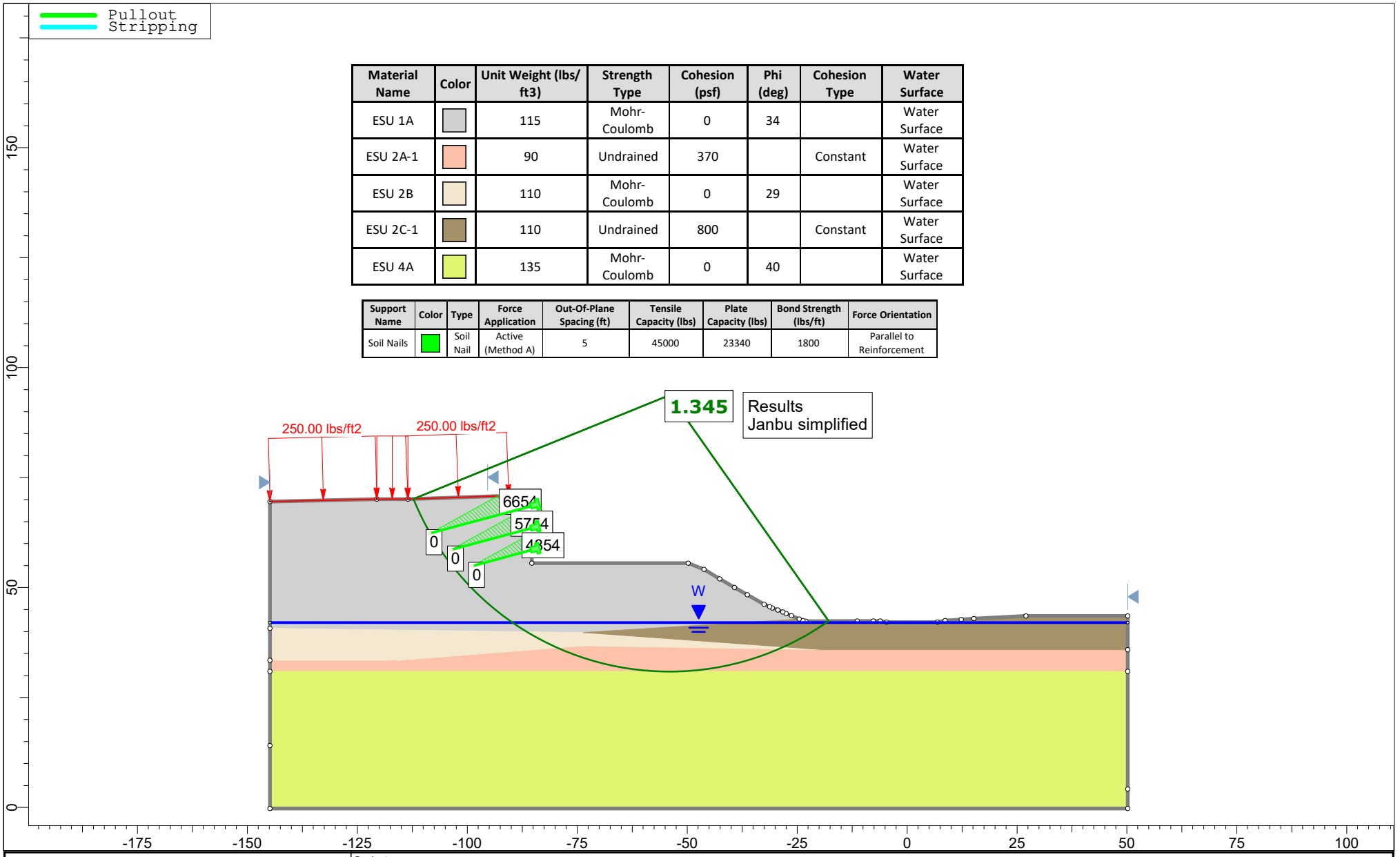
SLIDEINTERPRET 9.012

Project	RW 07.15R Temporary Soil Nail Wall		
Group	Group 1	*Scenario*	Master Scenario
Drawn By	Mike Little	*Company*	Atlas Geotechnical
Date	3/22/2021	*File Name*	07.15R TSNW Global Stability.slmd

Pullout
Stripping

Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Cohesion Type	Water Surface
ESU 1A		115	Mohr-Coulomb	0	34		Water Surface
ESU 2A-1		90	Undrained	370		Constant	Water Surface
ESU 2B		110	Mohr-Coulomb	0	29		Water Surface
ESU 2C-1		110	Undrained	800		Constant	Water Surface
ESU 4A		135	Mohr-Coulomb	0	40		Water Surface

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Tensile Capacity (lbs)	Plate Capacity (lbs)	Bond Strength (lbs/ft)	Force Orientation
Soil Nails		Soil Nail	Active (Method A)	5	45000	23340	1800	Parallel to Reinforcement



ATLAS GEOTECHNICAL

SLIDEINTERPRET 9.012

Project	RW 07.15R Temporary Soil Nail Wall		
Group	Group 1	*Scenario*	Master Scenario
Drawn By	Mike Little	*Company*	Atlas Geotechnical
Date	3/22/2021	*File Name*	07.15R TSNW Global Stability.slmd

rocscience

07.15R TSNW Global Stability
RW 07.15R Temporary Soil Nail Wall
Atlas Geotechnical
Date Created: 3/22/2021
Software Version: 9.012

Table of Contents

Slide Analysis Information

07.15R TSNW Global Stability

Project Summary

File Name:	07.15R TSNW Global Stability.slmd
Slide Modeler Version:	9.012
Compute Time:	00h:00m:01.640s
Project Title:	RW 07.15R Temporary Soil Nail Wall
Analysis:	Global Stability
Author:	Mike Little
Company:	Atlas Geotechnical
Date Created:	3/22/2021

General Settings

Units of Measurement:	Imperial Units
Time Units:	days
Permeability Units:	feet/second
Data Output:	Standard
Failure Direction:	Left to Right

Analysis Options

Slices Type:	Vertical
Analysis Methods Used	
	Janbu simplified
	Spencer
Number of slices:	50
Tolerance:	0.005
Maximum number of iterations:	75
Check malpha < 0.2:	Yes
Create Interslice boundaries at intersections with water tables and piezos:	Yes
Initial trial value of FS:	1
Steffensen Iteration:	Yes

Groundwater Analysis

Groundwater Method:	Water Surfaces
Pore Fluid Unit Weight [lbs/ft3]:	62.4
Use negative pore pressure cutoff:	Yes
Maximum negative pore pressure [psf]:	0
Advanced Groundwater Method:	None

Random Numbers

Pseudo-random Seed:	10116
Random Number Generation Method:	Park and Miller v.3

Surface Options

Surface Type:	Circular
Search Method:	Auto Refine Search
Divisions along slope:	20
Circles per division:	10
Number of iterations:	10
Divisions to use in next iteration:	50%
Composite Surfaces:	Disabled
Minimum Elevation:	Not Defined
Minimum Depth:	Not Defined
Minimum Area:	Not Defined
Minimum Weight:	Not Defined

Seismic Loading

Advanced seismic analysis:	No
Staged pseudostatic analysis:	No

Loading

1 Distributed Load present

Distributed Load 1	
Distribution:	Constant
Magnitude [psf]:	250
Orientation:	Normal to boundary

Materials

ESU 1A	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	115
Cohesion [psf]	0
Friction Angle [deg]	34
Water Surface	Water Table
Hu Value	1
ESU 2A-1	
Color	
Strength Type	Undrained
Unit Weight [lbs/ft3]	90
Cohesion [psf]	370
Cohesion Type	Constant
Water Surface	Water Table
Hu Value	1
ESU 2B	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	110
Cohesion [psf]	0
Friction Angle [deg]	29
Water Surface	Water Table
Hu Value	1
ESU 2C-1	
Color	
Strength Type	Undrained
Unit Weight [lbs/ft3]	110
Cohesion [psf]	800
Cohesion Type	Constant
Water Surface	Water Table
Hu Value	1
ESU 4A	
Color	
Strength Type	Mohr-Coulomb
Unit Weight [lbs/ft3]	135
Cohesion [psf]	0
Friction Angle [deg]	40
Water Surface	Water Table
Hu Value	1

Support

Soil Nails	
Color	
Support Type	Soil Nail
Force Application	Active
Force Orientation	Parallel to Reinforcement
Out-of-Plane Spacing [ft]	5
Tensile Capacity [lb]	45000
Plate Capacity [lb]	23340
Bond Strength [lb/ft]	1800
Material Dependent	No

Global Minimums

Method: janbu simplified

FS	1.344870
Center:	-53.995, 93.755
Radius:	62.878
Left Slip Surface Endpoint:	-112.261, 70.116
Right Slip Surface Endpoint:	-17.810, 42.332
Resisting Horizontal Force:	61599.7 lb
Driving Horizontal Force:	45803.4 lb
Active Horizontal Support Force:	-27.4017 lb
Maximum Single Support Force:	28.3684 lb
Total Support Force:	28.3684 lb
Total Slice Area:	1714.07 ft2
Surface Horizontal Width:	94.4507 ft
Surface Average Height:	18.1478 ft

Method: spencer

FS	1.449680
Center:	-53.995, 93.755
Radius:	62.878
Left Slip Surface Endpoint:	-112.261, 70.116
Right Slip Surface Endpoint:	-17.810, 42.332
Resisting Moment:	4.64076e+06 lb-ft
Driving Moment:	3.20123e+06 lb-ft
Resisting Horizontal Force:	60568.3 lb
Driving Horizontal Force:	41780.4 lb
Active Support Moment:	-461.558 lb-ft
Active Horizontal Support Force:	-27.4017 lb
Maximum Single Support Force:	28.3684 lb
Total Support Force:	28.3684 lb
Total Slice Area:	1714.07 ft2
Surface Horizontal Width:	94.4507 ft
Surface Average Height:	18.1478 ft

Global Minimum Support Data

Method: janbu simplified

Number of Supports: 3

Soil Nails

Support Type: Soil Nail

Start (x, y)	Length (ft)	L Inside SS (ft)	L Outside SS (ft)	Li (ft)	Lo (ft)	Force (lb)
-85.342, 68.511	24	23.9212	0.078801	23.9212	0.078801	28.3684
-85.342, 63.511	19	Not Effective	Not Effective	Not Effective	Not Effective	0
-85.342, 58.511	14	Not Effective	Not Effective	Not Effective	Not Effective	0

Method: spencer

Number of Supports: 3

Soil Nails

Support Type: Soil Nail

Start (x, y)	Length (ft)	L Inside SS (ft)	L Outside SS (ft)	Li (ft)	Lo (ft)	Force (lb)
-85.342, 68.511	24	23.9212	0.078801	23.9212	0.078801	28.3684
-85.342, 63.511	19	Not Effective	Not Effective	Not Effective	Not Effective	0
-85.342, 58.511	14	Not Effective	Not Effective	Not Effective	Not Effective	0

Valid and Invalid Surfaces

Method: janbu simplified

Number of Valid Surfaces:	8605
Number of Invalid Surfaces:	0

Method: spencer

Number of Valid Surfaces:	8537
Number of Invalid Surfaces:	68

Error Codes
Error Code -108 reported for 8 surfaces
Error Code -111 reported for 59 surfaces
Error Code -112 reported for 1 surface

Error Code Descriptions

The following errors were encountered during the computation:

-108 = Total driving moment or total driving force < 0.1. This is to limit the calculation of extremely high safety factors if the driving force is very small (0.1 is an arbitrary number).

-111 = Safety factor equation did not converge

-112 = The coefficient M-Alpha = cos(alpha)(1+tan(alpha)tan(phi)/F) < 0.2 for the final iteration of the safety factor calculation. This screens out some slip surfaces which may not be valid in the context of the analysis, in particular, deep seated slip surfaces with many high negative base angle slices in the passive zone.

Slice Data

Global Minimum Query (janbu simplified) - Safety Factor: 1.34487

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.87974	459.736	-65.8258	ESU 1A	0	34	117.07	157.444	233.422	0	233.422	494.229	494.229
2	1.87974	1307.33	-61.9146	ESU 1A	0	34	244.291	328.539	487.08	0	487.08	944.875	944.875
3	1.87974	2033.29	-58.4578	ESU 1A	0	34	368.423	495.481	734.581	0	734.581	1334.8	1334.8
4	1.87974	2672.1	-55.3152	ESU 1A	0	34	485.8	653.338	968.613	0	968.613	1670.6	1670.6
5	1.87974	3243.79	-52.4061	ESU 1A	0	34	599.706	806.526	1195.72	0	1195.72	1974.63	1974.63
6	1.87974	3761.29	-49.6785	ESU 1A	0	34	709.261	953.864	1414.16	0	1414.16	2249.86	2249.86
7	1.87974	4233.52	-47.0967	ESU 1A	0	34	814.703	1095.67	1624.4	0	1624.4	2501.02	2501.02
8	1.87974	4666.96	-44.6349	ESU 1A	0	34	916.267	1232.26	1826.9	0	1826.9	2731.57	2731.57
9	1.87974	5066.49	-42.2738	ESU 1A	0	34	1014.17	1363.93	2022.11	0	2022.11	2944.09	2944.09
10	1.87974	5435.89	-39.9982	ESU 1A	0	34	1108.62	1490.95	2210.42	0	2210.42	3140.6	3140.6
11	1.87974	5778.16	-37.7963	ESU 1A	0	34	1199.77	1613.54	2392.17	0	2392.17	3322.68	3322.68
12	1.87974	6095.73	-35.6583	ESU 1A	0	34	1246.72	1676.67	2485.77	0	2485.77	3380.25	3380.25
13	1.58992	5387.35	-33.7331	ESU 1A	0	34	1260.22	1694.83	2545.81	33.1228	2512.69	3387.32	3354.2
14	1.58992	5585.23	-32.0078	ESU 1A	0	34	1303.81	1753.46	2696.86	97.2533	2599.61	3511.82	3414.57
15	1.76814	5371.39	-30.2211	ESU 2B	0	29	956.137	1285.88	2480.18	160.394	2319.78	3037.14	2876.74
16	1.76814	3458.72	-28.3732	ESU 2B	0	29	584.361	785.889	1640.1	222.324	1417.78	1955.71	1733.39
17	1.76814	3637.73	-26.5569	ESU 2B	0	29	607.403	816.878	1753.38	279.692	1473.69	2056.97	1777.28
18	1.76814	3803.21	-24.7691	ESU 2B	0	29	629.537	846.645	1860.11	332.719	1527.39	2150.58	1817.86
19	2.0025	4470.49	-22.8914	ESU 2A-1	370	0	275.12	370	2116.13	384.554	1731.58	2232.3	1847.74
20	2.0025	4609.71	-20.9242	ESU 2A-1	370	0	275.12	370	2196.65	434.823	1761.82	2301.84	1867.01
21	2.0025	4734.81	-18.9825	ESU 2A-1	370	0	275.12	370	2269.69	480.203	1789.48	2364.32	1884.12
22	2.0025	4848.85	-17.0632	ESU 2A-1	370	0	275.12	370	2336.84	520.871	1815.97	2421.28	1900.41
23	2.0025	4953.18	-15.1635	ESU 2A-1	370	0	275.12	370	2398.84	556.98	1841.86	2473.4	1916.42
24	2.0025	5044.74	-13.2807	ESU 2A-1	370	0	275.12	370	2454.19	588.659	1865.54	2519.13	1930.47
25	2.0025	5123.81	-11.4124	ESU 2A-1	370	0	275.12	370	2503.1	616.018	1887.08	2558.63	1942.62
26	2.0025	5190.68	-9.55634	ESU 2A-1	370	0	275.12	370	2545.72	639.148	1906.57	2592.04	1952.89
27	2.0025	5245.55	-7.71037	ESU 2A-1	370	0	275.12	370	2582.2	658.125	1924.07	2619.45	1961.32
28	2.0025	5288.6	-5.87243	ESU 2A-1	370	0	275.12	370	2612.66	673.01	1939.65	2640.96	1967.95
29	2.0025	5319.96	-4.04055	ESU 2A-1	370	0	275.12	370	2637.2	683.85	1953.35	2656.63	1972.78
30	2.0025	5339.74	-2.21279	ESU 2A-1	370	0	275.12	370	2655.89	690.677	1965.21	2666.52	1975.84
31	2.85243	7616.14	0	ESU 2A-1	370	0	275.12	370	2670.05	693.091	1976.96	2670.05	1976.96
32	1.95551	5214.8	2.19135	ESU 2A-1	370	0	275.12	370	2677.26	690.757	1986.5	2666.73	1975.97
33	1.95551	5167.79	3.97613	ESU 2A-1	370	0	275.12	370	2661.83	684.181	1977.65	2642.7	1958.52
34	1.95551	4983.18	5.76479	ESU 2A-1	370	0	275.12	370	2576.09	673.781	1902.3	2548.31	1874.53
35	1.95551	4746.16	7.5591	ESU 2A-1	370	0	275.12	370	2463.62	659.525	1804.1	2427.12	1767.59
36	1.95551	4429.77	9.36092	ESU 2A-1	370	0	275.12	370	2310.69	641.371	1669.32	2265.33	1623.96
37	1.95551	4103.79	11.1721	ESU 2A-1	370	0	275.12	370	2152.98	619.263	1533.72	2098.65	1479.38
38	1.95551	3773.67	12.9947	ESU 2A-1	370	0	275.12	370	1993.34	593.133	1400.2	1929.85	1336.71
39	1.95551	3437.19	14.8308	ESU 2A-1	370	0	275.12	370	1830.64	562.898	1267.74	1757.79	1194.89
40	1.95551	3092.42	16.6827	ESU 2A-1	370	0	275.12	370	1663.95	528.459	1135.49	1581.5	1053.04
41	1.95551	2738.32	18.5527	ESU 2A-1	370	0	275.12	370	1492.77	489.698	1003.07	1400.43	910.734
42	1.95551	2386.38	20.4434	ESU 2A-1	370	0	275.12	370	1323.03	446.478	876.547	1220.47	773.994
43	1.95551	2055.84	22.3577	ESU 2A-1	370	0	275.12	370	1164.61	398.641	765.973	1051.46	652.814
44	1.09465	1005.76	23.8665	ESU 2B	0	29	282.559	380.005	1043.98	358.436	685.548	918.969	560.533
45	1.94433	1489.77	25.3925	ESU 2C-1	800	0	594.853	800	1048.95	314.53	734.422	766.591	452.061
46	1.94433	1102.81	27.3707	ESU 2C-1	800	0	594.853	800	875.56	254.33	621.23	567.604	313.274
47	1.94433	730.45	29.385	ESU 2C-1	800	0	594.853	800	711.105	188.763	522.342	376.128	187.365
48	1.94433	468.656	31.44	ESU 2C-1	800	0	594.853	800	605.191	117.515	487.676	241.52	124.005
49	1.94433	206.661	33.5413	ESU 2C-1	800	0	594.853	800	501.153	40.2135	460.94	106.812	66.5984
50	0.476601	8.61644	34.8688	ESU 2C-1	800	0	594.853	800	433.123	0	433.123	18.6281	18.6281

Global Minimum Query (spencer) - Safety Factor: 1.44968

Slice Number	Width [ft]	Weight [lbs]	Angle of Slice Base [deg]	Base Material	Base Cohesion [psf]	Base Friction Angle [deg]	Shear Stress [psf]	Shear Strength [psf]	Base Normal Stress [psf]	Pore Pressure [psf]	Effective Normal Stress [psf]	Base Vertical Stress [psf]	Effective Vertical Stress [psf]
1	1.87974	459.736	-65.8258	ESU 1A	0	34	96.82	140.358	208.09	0	208.09	423.784	423.784
2	1.87974	1307.33	-61.9146	ESU 1A	0	34	205.272	297.578	441.177	0	441.177	825.851	825.851
3	1.87974	2033.29	-58.4578	ESU 1A	0	34	314.105	455.352	675.086	0	675.086	1186.81	1186.81
4	1.87974	2672.1	-55.3152	ESU 1A	0	34	417.753	605.608	897.852	0	897.852	1501.51	1501.51
5	1.87974	3243.79	-52.4061	ESU 1A	0	34	520.589	754.687	1118.87	0	1118.87	1795.02	1795.02
6	1.87974	3761.29	-49.6785	ESU 1A	0	34	620.971	900.209	1334.62	0	1334.62	2066.28	2066.28
7	1.87974	4233.52	-47.0967	ESU 1A	0	34	718.917	1042.2	1545.13	0	1545.13	2318.68	2318.68
8	1.87974	4666.96	-44.6349	ESU 1A	0	34	814.497	1180.76	1750.54	0	1750.54	2554.72	2554.72
9	1.87974	5066.49	-42.2738	ESU 1A	0	34	907.773	1315.98	1951.03	0	1951.03	2776.28	2776.28
10	1.87974	5435.89	-39.9982	ESU 1A	0	34	998.848	1448.01	2146.77	0	2146.77	2984.85	2984.85
11	1.87974	5778.16	-37.7963	ESU 1A	0	34	1087.8	1576.96	2337.94	0	2337.94	3181.61	3181.61
12	1.87974	6095.73	-35.6583	ESU 1A	0	34	1137.47	1648.97	2444.7	0	2444.7	3260.8	3260.8
13	1.58992	5387.35	-33.7331	ESU 1A	0	34	1154.9	1674.23	2515.26	33.1228	2482.14	3286.45	3253.33
14	1.58992	5585.23	-32.0078	ESU 1A	0	34	1198.07	1736.82	2672.2	97.2533	2574.95	3421.06	3323.81
15	1.76814	5371.39	-30.2211	ESU 2B	0	29	866.798	1256.58	2427.32	160.394	2266.93	2932.24	2771.84
16	1.76814	3458.72	-28.3732	ESU 2B	0	29	528.813	766.609	1605.32	222.324	1383	1890.93	1668.61
17	1.76814	3637.73	-26.5569	ESU 2B	0	29	551.531	799.543	1722.11	279.692	1442.41	1997.77	1718.08
18	1.76814	3803.21	-24.7691	ESU 2B	0	29	573.924	832.006	1833.7	332.719	1500.98	2098.51	1765.79
19	2.0025	4470.49	-22.8914	ESU 2A-1	370	0	255.229	370	2011.53	384.554	1626.98	2119.3	1734.74
20	2.0025	4609.71	-20.9242	ESU 2A-1	370	0	255.229	370	2099.97	434.823	1665.15	2197.56	1762.73
21	2.0025	4734.81	-18.9825	ESU 2A-1	370	0	255.229	370	2182.12	480.203	1701.92	2269.92	1789.71
22	2.0025	4848.85	-17.0632	ESU 2A-1	370	0	255.229	370	2259.36	520.871	1738.49	2337.7	1816.83
23	2.0025	4953.18	-15.1635	ESU 2A-1	370	0	255.229	370	2332.31	556.98	1775.33	2401.48	1844.5
24	2.0025	5044.74	-13.2807	ESU 2A-1	370	0	255.229	370	2399.48	588.659	1810.82	2459.73	1871.07
25	2.0025	5123.81	-11.4124	ESU 2A-1	370	0	255.229	370	2460.97	616.018	1844.95	2512.49	1896.47
26	2.0025	5190.68	-9.55634	ESU 2A-1	370	0	255.229	370	2516.87	639.148	1877.72	2559.84	1920.69
27	2.0025	5245.55	-7.71037	ESU 2A-1	370	0	255.229	370	2567.24	658.125	1909.11	2601.79	1943.67
28	2.0025	5288.6	-5.87243	ESU 2A-1	370	0	255.229	370	2612.14	673.01	1939.13	2638.39	1965.38
29	2.0025	5319.96	-4.04055	ESU 2A-1	370	0	255.229	370	2651.59	683.85	1967.74	2669.62	1985.77
30	2.0025	5339.74	-2.21279	ESU 2A-1	370	0	255.229	370	2685.63	690.677	1994.95	2695.49	2004.81
31	2.85243	7616.14	0	ESU 2A-1	370	0	255.229	370	2718.87	693.091	2025.77	2718.87	2025.77
32	1.95551	5214.8	2.19135	ESU 2A-1	370	0	255.229	370	2745.4	690.757	2054.64	2735.63	2044.88
33	1.95551	5167.79	3.97613	ESU 2A-1	370	0	255.229	370	2745.74	684.181	2061.56	2728	2043.82
34	1.95551	4983.18	5.76479	ESU 2A-1	370	0	255.229	370	2674.5	673.781	2000.71	2648.73	1974.95
35	1.95551	4746.16	7.5591	ESU 2A-1	370	0	255.229	370	2575.08	659.525	1915.56	2541.21	1881.69
36	1.95551	4429.77	9.36092	ESU 2A-1	370	0	255.229	370	2432.81	641.371	1791.44	2390.74	1749.37
37	1.95551	4103.79	11.1721	ESU 2A-1	370	0	255.229	370	2283.98	619.263	1664.72	2233.57	1614.31
38	1.95551	3773.67	12.9947	ESU 2A-1	370	0	255.229	370	2131.4	593.133	1538.27	2072.51	1479.37
39	1.95551	3437.19	14.8308	ESU 2A-1	370	0	255.229	370	1973.85	562.898	1410.95	1906.27	1343.37
40	1.95551	3092.42	16.6827	ESU 2A-1	370	0	255.229	370	1810.17	528.459	1281.71	1733.68	1205.22
41	1.95551	2738.32	18.5527	ESU 2A-1	370	0	255.229	370	1639.69	489.698	1149.99	1554.03	1064.33
42	1.95551	2386.38	20.4434	ESU 2A-1	370	0	255.229	370	1468.56	446.478	1022.08	1373.42	926.946
43	1.95551	2055.84	22.3577	ESU 2A-1	370	0	255.229	370	1307.45	398.641	908.808	1202.47	803.831
44	1.09465	1005.76	23.8665	ESU 2B	0	29	333.336	483.23	1230.21	358.436	871.772	1082.73	724.291
45	1.94433	1489.77	25.3925	ESU 2C-1	800	0	551.846	800	1246.44	314.53	931.909	984.492	669.962
46	1.94433	1102.81	27.3707	ESU 2C-1	800	0	551.846	800	1063.22	254.33	808.891	777.529	523.199
47	1.94433	730.45	29.385	ESU 2C-1	800	0	551.846	800	886.998	188.763	698.235	576.239	387.476
48	1.94433	468.656	31.44	ESU 2C-1	800	0	551.846	800	773.834	117.515	656.319	436.456	318.941
49	1.94433	206.661	33.5413	ESU 2C-1	800	0	551.846	800	660.763	40.2135	620.549	294.932	254.718
50	0.476601	8.61644	34.8688	ESU 2C-1	800	0	551.846	800	587.855	0	587.855	203.328	203.328

Interslice Data

Global Minimum Query (janbu simplified) - Safety Factor: 1.34487

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	-112.261	70.1162	0	0	0
2	-110.381	65.9286	773.587	0	0
3	-108.501	62.406	2046.01	0	0
4	-106.621	59.3436	3591.17	0	0
5	-104.742	56.6274	5324.22	0	0
6	-102.862	54.1859	7131.16	0	0
7	-100.982	51.9711	8944.73	0	0
8	-99.1023	49.9485	10713.2	0	0
9	-97.2226	48.0926	12395.7	0	0
10	-95.3429	46.3837	13958.7	0	0
11	-93.4631	44.8065	15374.7	0	0
12	-91.5834	43.3487	16620.4	0	0
13	-89.7037	42	17635.4	0	0
14	-88.1137	40.9383	18331.9	0	0
15	-86.5238	39.9445	18936.3	0	0
16	-84.7557	38.9146	19798	0	0
17	-82.9875	37.9596	20329.6	0	0
18	-81.2194	37.0759	20803.8	0	0
19	-79.4513	36.26	21206.7	0	0
20	-77.4488	35.4145	22444.3	0	0
21	-75.4462	34.6488	23574.5	0	0
22	-73.4437	33.96	24586.3	0	0
23	-71.4412	33.3454	25471	0	0
24	-69.4387	32.8027	26221.2	0	0
25	-67.4362	32.33	26829.5	0	0
26	-65.4337	31.9258	27289.7	0	0
27	-63.4312	31.5887	27596.2	0	0
28	-61.4287	31.3175	27744.7	0	0
29	-59.4262	31.1116	27731.1	0	0
30	-57.4237	30.9701	27552.5	0	0
31	-55.4212	30.8927	27206.3	0	0
32	-52.5688	30.8927	26420.5	0	0
33	-50.6133	30.9676	25681.5	0	0
34	-48.6578	31.1035	24781	0	0
35	-46.7023	31.3009	23733.7	0	0
36	-44.7468	31.5604	22555.7	0	0
37	-42.7913	31.8828	21272.1	0	0
38	-40.8357	32.269	19901.8	0	0
39	-38.8802	32.7203	18463.6	0	0
40	-36.9247	33.2381	16977	0	0
41	-34.9692	33.8241	15463.1	0	0
42	-33.0137	34.4804	13944.7	0	0
43	-31.0582	35.2093	12441.6	0	0
44	-29.1027	36.0137	10966.2	0	0
45	-28.008	36.498	10150.8	0	0
46	-26.0637	37.4209	8024.62	0	0
47	-24.1194	38.4275	5985.17	0	0
48	-22.1751	39.5224	4048.46	0	0
49	-20.2307	40.7111	2170.95	0	0
50	-18.2864	42	366.875	0	0
51	-17.8098	42.3321	0	0	0

Global Minimum Query (spencer) - Safety Factor: 1.44968

Slice Number	X coordinate [ft]	Y coordinate - Bottom [ft]	Interslice Normal Force [lbs]	Interslice Shear Force [lbs]	Interslice Force Angle [deg]
1	-112.261	70.1162	0	0	0
2	-110.381	65.9286	705.445	134.66	10.807
3	-108.501	62.406	1889.24	360.63	10.807
4	-106.621	59.3436	3353.87	640.208	10.807
5	-104.742	56.6274	5022.01	958.634	10.807
6	-102.862	54.1859	6789.27	1295.98	10.807
7	-100.982	51.9711	8591.71	1640.04	10.807
8	-99.1023	49.9485	10378.8	1981.18	10.807
9	-97.2226	48.0926	12109.6	2311.56	10.807
10	-95.3429	46.3837	13749.8	2624.65	10.807
11	-93.4631	44.8065	15270.2	2914.87	10.807
12	-91.5834	43.3487	16645.6	3177.41	10.8069
13	-89.7037	42	17808.7	3399.43	10.8069
14	-88.1137	40.9383	18638.6	3557.86	10.807
15	-86.5238	39.9445	19385	3700.33	10.807
16	-84.7557	38.9146	20348.9	3884.32	10.807
17	-82.9875	37.9596	20944.7	3998.06	10.807
18	-81.2194	37.0759	21489.2	4102	10.807
19	-79.4513	36.26	21968.1	4193.41	10.807
20	-77.4488	35.4145	23156.6	4420.28	10.807
21	-75.4462	34.6488	24252.2	4629.41	10.807
22	-73.4437	33.96	25243	4818.55	10.807
23	-71.4412	33.3454	26119.4	4985.85	10.807
24	-69.4387	32.8027	26872.9	5129.67	10.807
25	-67.4362	32.33	27494.7	5248.38	10.807
26	-65.4337	31.9258	27977.3	5340.48	10.807
27	-63.4312	31.5887	28313.5	5404.66	10.807
28	-61.4287	31.3175	28497.2	5439.74	10.807
29	-59.4262	31.1116	28523	5444.65	10.807
30	-57.4237	30.9701	28385.8	5418.46	10.807
31	-55.4212	30.8927	28081.3	5360.34	10.807
32	-52.5688	30.8927	27351.6	5221.05	10.807
33	-50.6133	30.9676	26645.9	5086.34	10.807
34	-48.6578	31.1035	25772.4	4919.61	10.807
35	-46.7023	31.3009	24744.2	4723.33	10.807
36	-44.7468	31.5604	23575.7	4500.28	10.807
37	-42.7913	31.8828	22291.2	4255.09	10.807
38	-40.8357	32.269	20908.8	3991.21	10.807
39	-38.8802	32.7203	19446.7	3712.12	10.807
40	-36.9247	33.2381	17924.4	3421.53	10.807
41	-34.9692	33.8241	16363.3	3123.54	10.807
42	-33.0137	34.4804	14787	2822.63	10.8069
43	-31.0582	35.2093	13216.2	2522.8	10.807
44	-29.1027	36.0137	11664.4	2226.57	10.807
45	-28.008	36.498	10702.8	2043.02	10.807
46	-26.0637	37.4209	8477.01	1618.15	10.807
47	-24.1194	38.4275	6331.35	1208.57	10.807
48	-22.1751	39.5224	4284.73	817.896	10.807
49	-20.2307	40.7111	2289.43	437.022	10.807
50	-18.2864	42	362.307	69.1595	10.807
51	-17.8098	42.3321	0	0	0

Entity Information

Group 1

Shared Entities

Type	Coordinates (x,y)
External Boundary	-144.921, -0.246 50.197, -0.246 50.197, 4.164 50.197, 30.8927 50.197, 35.849 50.197, 43.499 27.013, 43.499 15.205, 42.939 12.323, 42.694 8.632, 42.449 6.908, 42.131 -4.633, 42.131 -6.104, 42.378 -7.661, 42.378 -11.354, 42.378 -23.027, 42.295 -23.663, 42.475 -24.5235, 42.8318 -26.28, 43.56 -27.492, 44.052 -28.266, 44.411 -29.413, 44.854 -30.653, 45.349 -31.26, 45.651 -32.501, 46.189 -36.353, 48.332 -39.26, 49.976 -42.621, 51.937 -46.18, 54.112 -49.789, 55.511 -85.342, 55.511 -85.342, 71.006 -86.849, 71.006 -113.495, 70.073 -120.618, 70.073 -144.921, 69.541 -144.921, 40.6963 -144.921, 33.438 -144.921, 30.8927 -144.921, 14.0512
Material Boundary	-144.921, 30.8927 50.197, 30.8927
Material Boundary	-144.921, 33.438 -115.813, 33.438 -73.344, 36.734 -18.99, 35.849 50.197, 35.849
Material Boundary	-144.921, 40.6963 -73.587, 39.778 -18.99, 35.849
Material Boundary	-73.587, 39.778 -24.5235, 42.8318

Scenario-based Entities

Type	Coordinates (x,y)	Master Scenario
Water Table	-144.921, 42 50.197, 42	Assigned to: ESU 1A ESU 2A-1 ESU 2B ESU 2C-1 ESU 4A
Distributed Load	-90.5414, 70.8767 -113.495, 70.073 -120.618, 70.073 -144.921, 69.541	Constant DistributionOrientation: Normal to boundaryMagnitude: 250 lbs/ft2Creates Excess Pore Pressure: No

Appendix B – May Creek Bridge Lateral Stability Memo

Memorandum

Project: I-405 R2B

Subject: RW 07.15R TSNW

Date: 16 July 2021

Soil Nail Wall Influence on May Creek Bridge Abutment

RW 07.15R TSNW is a temporary soil nail wall 66 ft long and 15 feet high that will shore the east side of the embankment on the north end of the May Creek Bridge. Six of the 32 nails are close to the north bridge abutment, arranged in a column of three on each side. Comment No. 4 of WSDOT's review requests the designer to ensure that soil nail forces do not affect the May Creek Bridge abutment.

The concerning failure mode appears to be these six soil nails dragging the bridge laterally out of its embankment. Though such instability seems implausible, WSDOT cites RFP 2.13.4.1 requiring analysis of all existing structural elements whose load carrying capacities are altered by the work. Excavating a vertical face alongside the bridge and supporting the cut with soil nails does, in fact, change the stress state in the embankment and, by extension, the bridge abutment.

Section 7.2.1 of Drill Tech Drilling & Shoring's (DTDS's) 21 June 2021 computations report 12.12 kips maximum nail head force inclined 15° above horizontal. These nail forces resolve into the ground as shear along the soil/grout interface behind the hypothetical failure wedge.

Assuming that half of each nail's shear force accrues to the bridge abutment (the other half resolves into embankment soils away from the bridge), and that the upward component is inconsequential relative to the bridge dead weight, the six nearby nails exert a combined 35-kip lateral force on the bridge abutment.

The 40-ft wide bridge abutment is embedded about 15 feet in compacted fill. Assuming K_0 lateral earth pressures, a 32° soil/concrete interface, and 5 feet of width that might be inside the active failure plane, the stabilizing soil friction on the north abutment face is 138 kips. This stabilizing force is about four times larger than the soil nail force, indicating that the nail forces are not large enough to adversely impact abutment stability.

More stabilizing forces that could be quantified if simple friction were not sufficient include:

1. Friction on the entire inboard bridge abutment face,
2. Friction along the abutment base,
3. The bridge foundation lateral capacity. Considering that the foundation was designed to resist transverse seismic loads, these stabilizing forces might be quite large.

On this basis we conclude that the stress state changes related to TSNW construction are not large enough to impact the existing bridge.

Appendix C – Field Test Reports

DRILL-TECH DRILLING & SHORING, INC.
2200 Wymore Way, Antioch, CA 94509
Office: (925)978-2060 // Fax: (925)978-2063

Project:	I-405 Renton to Bellevue Widening & Express Toll Lanes
Location:	Renton to Bellevue, WA
Foreman:	Scott Brown
Date:	10/11/2021
Job No.	20018

Sheet 1

Soil Nail Verification Test

Between SN 4 & 5; Elev 65.5

Soil Nail No: VN1
Embedment Length (ft.) 10
Retaining Wall No: RW 7.15R

TEST LOAD	
Lb (ft):	10
Qd (kips/ft):	1.7
DTL (kips):	17

6-inch Diameter Hole

Nail pulling out at load above 2400 psi (1.50 DTL) attempting to reach 2800 psi (1.75 DTL), verification test failed to reach maximum verification test load

Ram Information
Ram No.: 50-6-9
Gauge No.: 50-6-9A
Calibr. Date 09/28/21

Bumped load back up to 2,400 psi at 30 and 60-minutes during the creep test

Testing Schedule

Load	Load	50-6-9A	Elongation (Inches)											
Level	(kips)	(psi)	1 Min.	2 Min.	3 Min.	4 Min.	5 Min.	6 Min.	10 min.	20 min.	30 Min.	40 Min.	50 Min.	60 Min.
AL (0.10 DTL)	1.70	200	0.000											
0.25 DTL	4.25	350	0.027	Reading at beginning of 10-minute hold					0.027					
0.50 DTL	8.50	750	0.095	Reading at beginning of 10-minute hold					0.095					
0.75 DTL	12.75	1100	0.180	Reading at beginning of 10-minute hold					0.195					
1.00 DTL	17.00	1550	0.299	Reading at beginning of 10-minute hold					0.313					
1.25 DTL	21.25	1950	0.452	Reading at beginning of 10-minute hold					0.479					
1.50 DTL (Creep*)	25.50	2400	1.155	1.159	1.161	1.162	1.162	1.163	1.164	1.167	**1.201**	1.210	1.211	**1.260**
1.75 DTL	29.75	2800	NR	Reading at beginning of 10-minute hold					NR					
2.00 DTL (MTL)	34.00	3250	NR	Reading at beginning of 10-minute hold					NR					
AL (0.10 DTL)	1.70	150	1.480											

AL = Alignment Load; DTL = Design Test Load

*Hold the load to within 2 percent and measure and record soil nail movement at 1, 2, 3, 4, 5, 6, 10, 20, 30, 40, 50, and 60 minutes

Verification Test Acceptance Criteria:

A verification tested nail with a 60-minute load hold at 1.50TL is acceptable if:

1) Creep rate does not exceed 0.08 inch from 1-min to 60-minutes.

2) Total movement measured at the Maximum Test Load (MTL=2.00 DTL) exceeds 80 percent of theoretical elastic elongation of the non-bonded length.

Elongation Calculations

MTL = 34.00 kips Lu (Unbonded Length) = 7 ft.
E = 29000 ksi A (X-Section Area) = 0.600 sq. in #7 Bar

Theoretical Elongation	=	0.1559	inches
80% Theoretical Elongation	=	0.1247	inches
Actual Elongation	=	NA	inches

Ram Load	Load Cell Reading
1.70	2.80
4.25	4.35
8.50	8.00
12.75	11.80
17.00	15.00
21.25	19.20
25.50	24.00
29.75	NR
34.00	NR
1.70	NR

Total Creep Movement From 1- to 60-minutes: 0.105 inches >0.08-in Fail

DRILLTECH DRILLING & SHORING, INC.
2200 Wymore Way, Antioch, CA 94509
Office: (925)978-2060 // Fax: (925)978-2063

Project:	I-405 Renton to Bellevue Widening & Express Toll Lanes
Location:	Renton to Bellevue, WA
Foreman:	Scott Brown
Date:	10/11/2021
Job No.	20018

Sheet 1

Soil Nail Verification Test

Between SN 11 & 12; Elev 67.5

Soil Nail No: VN2
Embedment Length (ft.) 10
Retaining Wall No: RW 7.15R

TEST LOAD	
Lb (ft):	10
Qd (kips/ft):	1.7
DTL (kips):	17

6-inch Diameter Hole

Nail pulling out at load above 2200 psi before reaching 2400 psi (1.50 DTL), verification test failed to reach maximum verification test load

Ram Information
Ram No.: 50-6-9
Gauge No.: 50-6-9A
Calibr. Date 09/28/21

Testing Schedule

Load Level	Load (kips)	50-6-9A (psi)	Elongation (Inches) 1 Min.	2 Min.	3 Min.	4 Min.	5 Min.	6 Min.	10 min.	20 min.	30 Min.	40 Min.	50 Min.	60 Min.
AL (0.10 DTL)	1.70	200	0.000											
0.25 DTL	4.25	350	0.029	Reading at beginning of 10-minute hold					0.031					
0.50 DTL	8.50	750	0.045	Reading at beginning of 10-minute hold					0.050					
0.75 DTL	12.75	1100	0.316	Reading at beginning of 10-minute hold					0.316					
1.00 DTL	17.00	1550	0.574	Reading at beginning of 10-minute hold					0.580					
1.25 DTL	21.25	1950	1.028	Reading at beginning of 10-minute hold					1.034					
1.50 DTL (Creep*)	25.50	2400	2.123	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR	NR
1.75 DTL	29.75	2800	NR	Reading at beginning of 10-minute hold					NR					
2.00 DTL (MTL)	34.00	3250	NR	Reading at beginning of 10-minute hold					NR					
AL (0.10 DTL)	1.70	200	1.880											

AL = Alignment Load; DTL = Design Test Load

*Hold the load to within 2 percent and measure and record soil nail movement at 1, 2, 3, 4, 5, 6, 10, 20, 30, 40, 50, and 60 minutes

Verification Test Acceptance Criteria:

A verification tested nail with a 60-minute load hold at 1.50TL is acceptable if:

1) Creep rate does not exceed 0.08 inch from 1-min to 60-minutes.

2) Total movement measured at the Maximum Test Load (MTL=2.00 DTL) exceeds 80 percent of theoretical elastic elongation of the non-bonded length.

Elongation Calculations

MTL = 34.00 kips
Lu (Unbonded Length) = 7 ft.
E = 29000 ksi
A (X-Section Area) = 0.600 sq. in #7 Bar

Theoretical Elongation	=	0.1559	inches
80% Theoretical Elongation	=	0.1247	inches
Actual Elongation	=	NA	inches

Ram Load	Load Cell Reading
1.70	2.90
4.25	4.50
8.50	8.00
12.75	NR
17.00	15.70
21.25	20.10
25.50	NR
29.75	NR
34.00	NR
1.70	NR

Could not reach load necessary to perform full creep test

Total Creep Movement From 1- to 60-minutes: NA inches

DRILLTECH DRILLING & BORING, INC.
2200 Wymore Way, Antioch, CA 94509
Office: (925)978-2060 // Fax: (925)978-2063

Project:	I-405 Renton to Bellevue Widening & Express Toll Lanes		
Location:	Renton to Bellevue, WA		
Foreman:	Scott Brown		
Date:	10/16/2021	Job No.	20018

Sheet 1

Soil Nail Verification Test 3 & 4 ELEV 65.5

8-Inch Diameter Hole

Nail pulling out at load above 2700 psi before reaching 2800 psi (1.75 DTL), verification test failed to reach maximum verification test load

Between SNs ~~1 & 12, Elev 87.5~~

Soil Nail No: VN1.1
Embedment Length (ft.) 10
Retaining Wall No: RW 7.15R

TEST LOAD	
Lb (ft):	10
Qd (kips/ft):	1.7
DTL (kips):	17

Ram Information
Ram No.: 50-6-9
Gauge No.: 50-6-9A
Calibr. Date 09/28/21

Testing Schedule

Load	Load	50-6-9A	Elongation (Inches)											
Level	(kips)	(psi)	1 Min.	2 Min.	3 Min.	4 Min.	5 Min.	6 Min.	10 min.	20 min.	30 Min.	40 Min.	50 Min.	60 Min.
AL (0.10 DTL)	1.70	200	0.000											
0.25 DTL	4.25	350	0.010	Reading at beginning of 10-minute hold					0.010					
0.50 DTL	8.50	750	0.064	Reading at beginning of 10-minute hold					0.072					
0.75 DTL	12.75	1100	0.156	Reading at beginning of 10-minute hold					0.167					
1.00 DTL	17.00	1550	0.294	Reading at beginning of 10-minute hold					0.311					
1.25 DTL	21.25	1950	NR	Reading at beginning of 10-minute hold					NR					
1.50 DTL (Creep*)	25.50	2400	1.148	1.151	1.151	1.151	1.151	1.151	1.152	1.152	1.152	1.170	1.171	1.172
1.75 DTL	29.75	2800	2.240	Reading at beginning of 10-minute hold					NR					
2.00 DTL (MTL)	34.00	3250	NR	Reading at beginning of 10-minute hold					NR					
AL (0.10 DTL)	1.70	200	NR											

AL = Alignment Load; DTL = Design Test Load

*Hold the load to within 2 percent and measure and record soil nail movement at 1, 2, 3, 4, 5, 6, 10, 20, 30, 40, 50, and 60 minutes

Verification Test Acceptance Criteria:

A verification tested nail with a 60-minute load hold at 1.50TL is acceptable if:

1) Creep rate does not exceed 0.08 inch from 1-min to 60-minutes.

2) Total movement measured at the Maximum Test Load (MTL=2.00 DTL) exceeds 80 percent of theoretical elastic elongation of the non-bonded length.

Elongation Calculations

MTL = 34.00 kips — Lu (Unbonded Length) = 7 ft.
E = 29000 ksi — A (X-Section Area) = 0.600 sq. in — #7 Bar

Theoretical Elongation	=	0.1559	inches
80% Theoretical Elongation	=	0.1247	inches
Actual Elongation	=	NA	inches

Ram Load	Load Cell Reading
1.70	2.80
4.25	3.50
8.50	7.70
12.75	11.80
17.00	16.50
21.25	NR
25.50	24.40
29.75	25.20
34.00	NR
1.70	NR

Total Creep Movement From 1- to 60-minutes: 0.024 inches < 0.08" Pass

DRILLTECH DRILLING & SHORING, INC.
2200 Wymore Way, Antioch, CA 94509
Office: (925)978-2060 // Fax: (925)978-2063

Project:	I-405 Renton to Bellevue Widening & Express Toll Lanes		
Location:	Renton to Bellevue, WA		
Foreman:	Scott Brown		
Date:	10/16/2021	Job No.	20018

Sheet 1

Soil Nail Verification Test

8-Inch Diameter Hole

Nail pulling out at load at 2400 psi (1.50 DTL) during creep test at 20-min, verification test failed during creept test and to reach maximum verification test load

Ram Information
Ram No.: 50-6-9
Gauge No.: 50-6-9A
Calibr. Date 09/28/21

Between SNs 10 & 11; Elev 68.0

Soil Nail No: VN2.1
Embedment Length (ft.) 10
Retaining Wall No: RW 7.15R

TEST LOAD	
Lb (ft):	10
Qd (kips/ft):	1.7
DTL (kips):	17

Testing Schedule

Load Level	Load (kips)	50-6-9A (psi)	Elongation (Inches) 1 Min.	2 Min.	3 Min.	4 Min.	5 Min.	6 Min.	10 min.	20 min.	30 Min.	40 Min.	50 Min.	60 Min.
AL (0.10 DTL)	1.70	200	0.000											
0.25 DTL	4.25	350	0.018	Reading at beginning of 10-minute hold					0.200					
0.50 DTL	8.50	750	0.108	Reading at beginning of 10-minute hold					0.108					
0.75 DTL	12.75	1100	0.295	Reading at beginning of 10-minute hold					0.305					
1.00 DTL	17.00	1550	0.531	Reading at beginning of 10-minute hold					0.559					
1.25 DTL	21.25	1950	0.844	Reading at beginning of 10-minute hold					0.888					
1.50 DTL (Creep*)	25.50	2400	1.609	1.609	1.648	1.648	1.649	1.649	1.651	1.866	NR	NR	NR	NR
1.75 DTL	29.75	2800	NR						NR					
2.00 DTL (MTL)	34.00	3250	NR						NR					
AL (0.10 DTL)	1.70	150	NR											

AL = Alignment Load; DTL = Design Test Load

*Hold the load to within 2 percent and measure and record soil nail movement at 1, 2, 3, 4, 5, 6, 10, 20, 30, 40, 50, and 60 minutes

Verification Test Acceptance Criteria:

A verification tested nail with a 60-minute load hold at 1.50TL is acceptable if:

1) Creep rate does not exceed 0.08 inch from 1-min to 60-minutes.

2) Total movement measured at the Maximum Test Load (MTL=2.00 DTL) exceeds 80 percent of theoretical elastic elongation of the non-bonded length.

Elongation Calculations

MTL = 34.00 kips Lu (Unbonded Length) = 7 ft.
E = 29000 ksi A (X-Section Area) = 0.600 sq. in #7 Bar

Theoretical Elongation	=	0.1559	inches
80% Theoretical Elongation	=	0.1247	inches
Actual Elongation	=	NA	inches

Ram Load	Load Cell Reading
1.70	3.15
4.25	4.70
8.50	8.50
12.75	12.30
17.00	15.80
21.25	20.00
25.50	22.50
29.75	NR
34.00	NR
1.70	NR

Failed during the creep test

Total Creep Movement From 1- to 60-minutes: NA inches

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Special Inspection Report

PROJECT NAME WSDOT I-405 Renton to Bellevue Design Build		PROJECT NO. PS20-20378-0	FIELD REPORT NO. 2021-10-07~JF T. SOIL NAIL WALL 07.15R
ADDRESS 07.15R: Temp Soil Nail Wall		DATE October 7, 2021	PAGE 1 OF 5
CITY OR COUNTY Renton, WA	PERMIT NO.	ARRIVAL TIME 8:00AM	DEPARTURE TIME 3:00PM
CLIENT WSDOT	WOOD ENGINEER OF RECORD/PHONE NO. Milan Radic / (425) 589-4202		
GENERAL CONTRACTOR FLJV/ Billy Myers (360) 515-8657	WOOD FIELD REPRESENTATIVE/ MOBILE NO. Jimmy Francisco / (323) 203-5126		
SUBCONTRACTOR Drill Tech Drilling and Shoring Inc./ Bill Creger (510) 598-0609	WEATHER Partly Cloudy, 60's degrees F		
TYPE OF WORK PERFORMED Fill Wall 07.15R: Temporary Soil Nail Wall			
EQUIPMENT USED FLJV: CAT 305E2 CR Mini Excavator			

COMMENTS

Wall 07.15R: Temporary Soil Nail Wall

Wood Environmental & Infrastructure Solutions Inc. (Wood) was onsite to observe the stability of the open cut during the excavation of the test pit for temporary soil nail wall 7.15R. Upon arrival, FLJV was locating the edges of the test pit and mobilized approximately 5 feet to the East of the existing May Creek bridge, north abutment, approximately wall Sta 0+24 and Sta 0+39. Location of test pit (designated as TP-1) is shown on the Site Plan on Page 3. The current ground elevation was estimated as 70 feet. Based on conversation between Mike (FLJV) and Bill Creger (Drill Tech Drilling), it was determined that the depth of the test pit be 10 feet below current ground surface (bgs) and the length along the trench bottom be 15 feet. A small berm was created at 1½H:1V (horizontal to vertical) extending downwards to the 10-foot vertical cut as shown in the sketch below:

☒ The contents of this field report were discussed with the contractor's on-site representative.

☐ A preliminary copy of this field report was left on site. All recommendations contained herein are subject to change pending review by the WOOD Engineer of Record.

WOOD FIELD REPRESENTATIVE

WOOD ENGINEER OF RECORD

Wood Environment & Infrastructure Solutions, Inc. (Wood)
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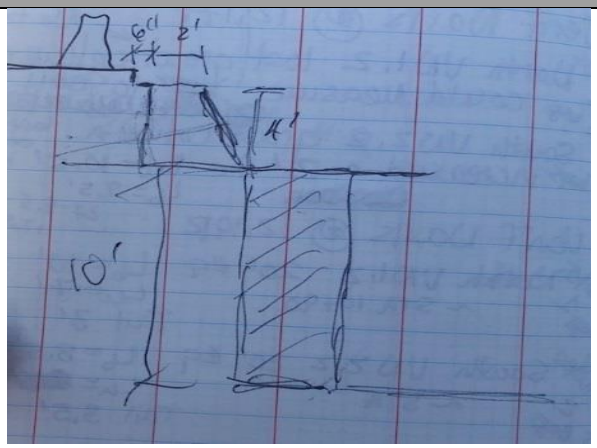
Daily field report

PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
WSDOT I-405 Renton to Bellevue Design Build	PS20-20378-0	2021-10-07~JF T. SOIL NAIL WALL 07.15R
ADDRESS	DATE	PAGE
Renton, WA	October 7, 2021	2 OF 6

COMMENTS



FLJV started excavating TP-1 at 8:40am. The near surface soils consisted of silty sand with gravel. At approximately 7 feet bgs, the soil was alternating with thin layers of interbedded silt and appeared stiff. No groundwater or caving was observed during the excavation for TP-1 (see the attached Field Log of Test Pit for soil conditions). The bottom of excavation (10 feet) was reached at 11:00am (See Photo 1). Immediately after the completion of excavation, test pit TP-1 caved along the west excavation face (See Photo 2). The caving occurred at the contact between the bottom of the berm and the top of the west excavation face due to probable vibrations of the May Creek bridge, traffic conditions, and the berm not being far from the edge of the vertical cut. At 11:30am, FLJV started backfilling Test Pit TP-1 with excavated soil and "bucket" compacted with the mini excavator. FLJV decided to excavate a second test pit (designated as TP-2) at approximately 10½ feet to the East of the existing May Creek bridge and between Sta 0+51 and Sta 0+66 (see Site Plan on Page 3). The ground elevation was estimated as 69 feet. In order to provide a safe excavation for test pit TP-2, a berm was created similar to the original test pit TP-1, with the exception that the berm was 2 feet away from the vertical cut as to not affect the stability of the test pit:

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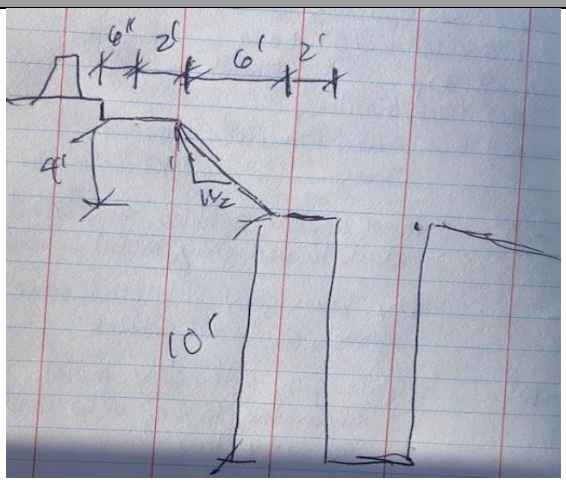
Daily field report

PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
WSDOT I-405 Renton to Bellevue Design Build	PS20-20378-0	2021-10-07~JF T. SOIL NAIL WALL 07.15R
ADDRESS	DATE	PAGE
Renton, WA	October 7, 2021	3 OF 6

COMMENTS



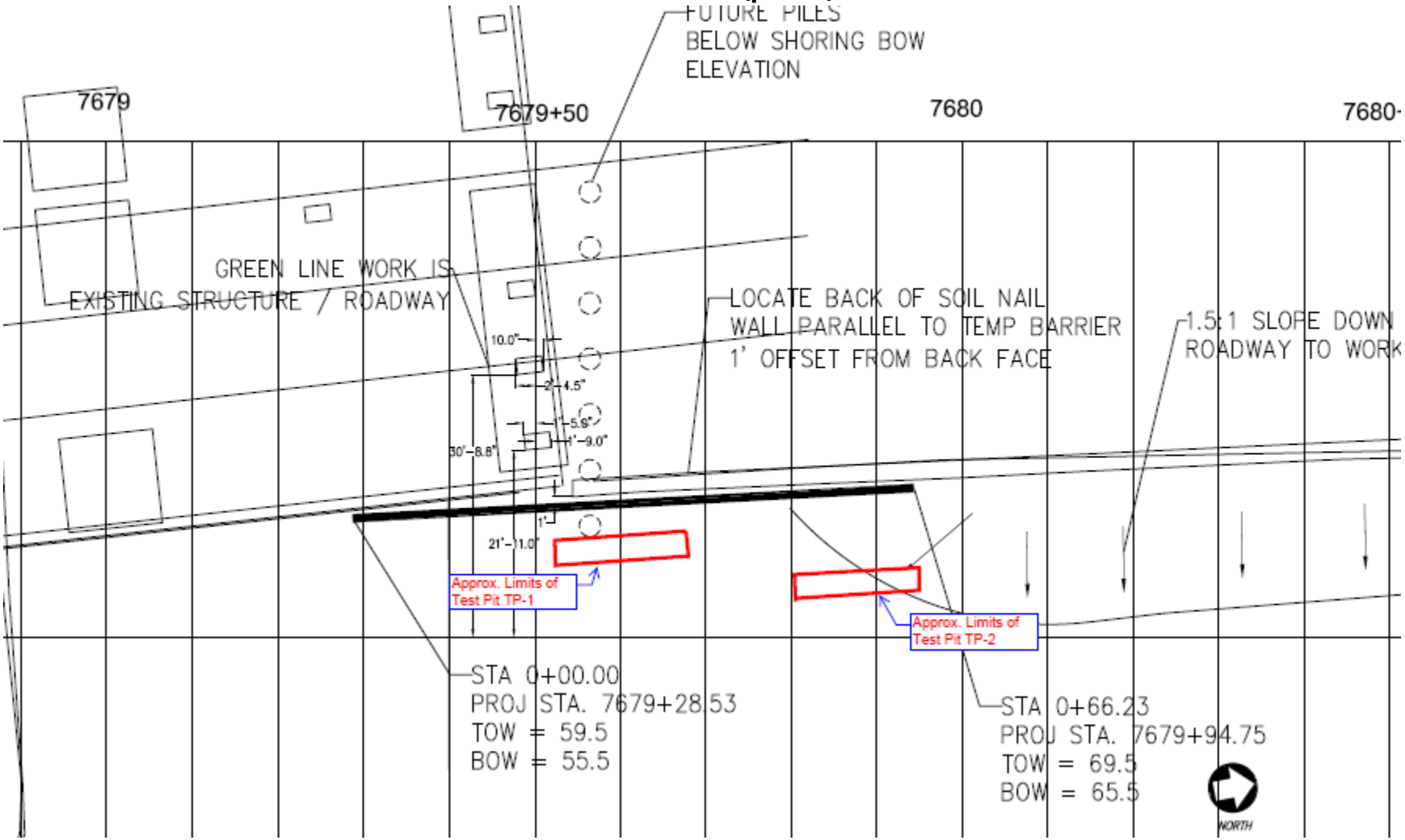
At 01:40pm, FLJV had excavated approximately 5 feet bgs at test pit TP-2. FLJV finished excavating TP-2 at approximately 02:30pm. Wood observed that the soil conditions at TP-2 was relatively similar to the soil conditions encountered at TP-1, with the exception that asphalt was encountered at 7 feet bgs at TP-2 near the south excavation face. No caving or water seepage was observed during the excavation for TP-2. See Photo 3 for a picture that was taken after the completion of test pit TP-2. FLJV fenced the area as to provide a safety perimeter for the test pit. Wood departed site at 03:00pm.

Representatives from Kleinfelder (Jimi), WSDOT (Paul Jones), and Drill Tech Drilling (Bill Creger) were there onsite to observe the excavation of the test pits.

WOOD FIELD REPRESENTATIVE

WOOD ENGINEER OF RECORD

Site Plan: SN2 (partial)



PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
WSDOT I-405 Renton to Bellevue Design Build	PS20-20378-0	2021-10-07~JF T. SOIL NAIL WALL 07.15R
DESCRIPTION	**DATE**	**PAGE**
SN2 partial site plan, provided by Drill Tech Drilling and Shoring Inc	October 7, 2021	3 OF 5

Photo 1: View towards excavation bottom of TP-1. Small berm shown to the left extending downwards to the 10-foot vertical cut.

Photo 2: View towards excavation bottom of TP-1. Small berm to the right. Test pit TP-1 caved at the contact of the bottom of berm.

PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
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DESCRIPTION	DATE	PAGE
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Photo 3: View towards excavation bottom of test pit TP-2 (standing behind the south edge of test pit)

PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
WSDOT I-405 Renton to Bellevue Design Build	PS20-20378-0	2021-10-07~JF T. SOIL NAIL WALL 07.15R
DESCRIPTION	DATE	PAGE
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FIELD LOG OF TEST PIT

LOGGED BY: J.F. SUBCONTRACTOR: _____

JOB NO: PS202203780 DATE: 10/7/21 LOCATION: TSNW 7.15R

LOG OF TEST PIT TP-1 PROJECT: I-405 RTB

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) SILTY SAND with GRAVEL (SM) - moist, brown, some roots, minor angular cobbles	None observed	—	—	0
(2) SILTY SAND with GRAVEL (SM) as above, becomes gray.			5'	2
(3) Alternating with layers of SILT (ML), moist, appears stiff, gray, trace to few fine grained sand, clayey			7'	4
				6
				8
				10
				12

Sketch of West Pit Side — Surface Elevation: Approx. 70 Ft.

Horizontal Distance in Feet: 0, 3 (2e), 6 (4s), 9 (6s), 12 (8s), 15 (10s), 18 (12s)

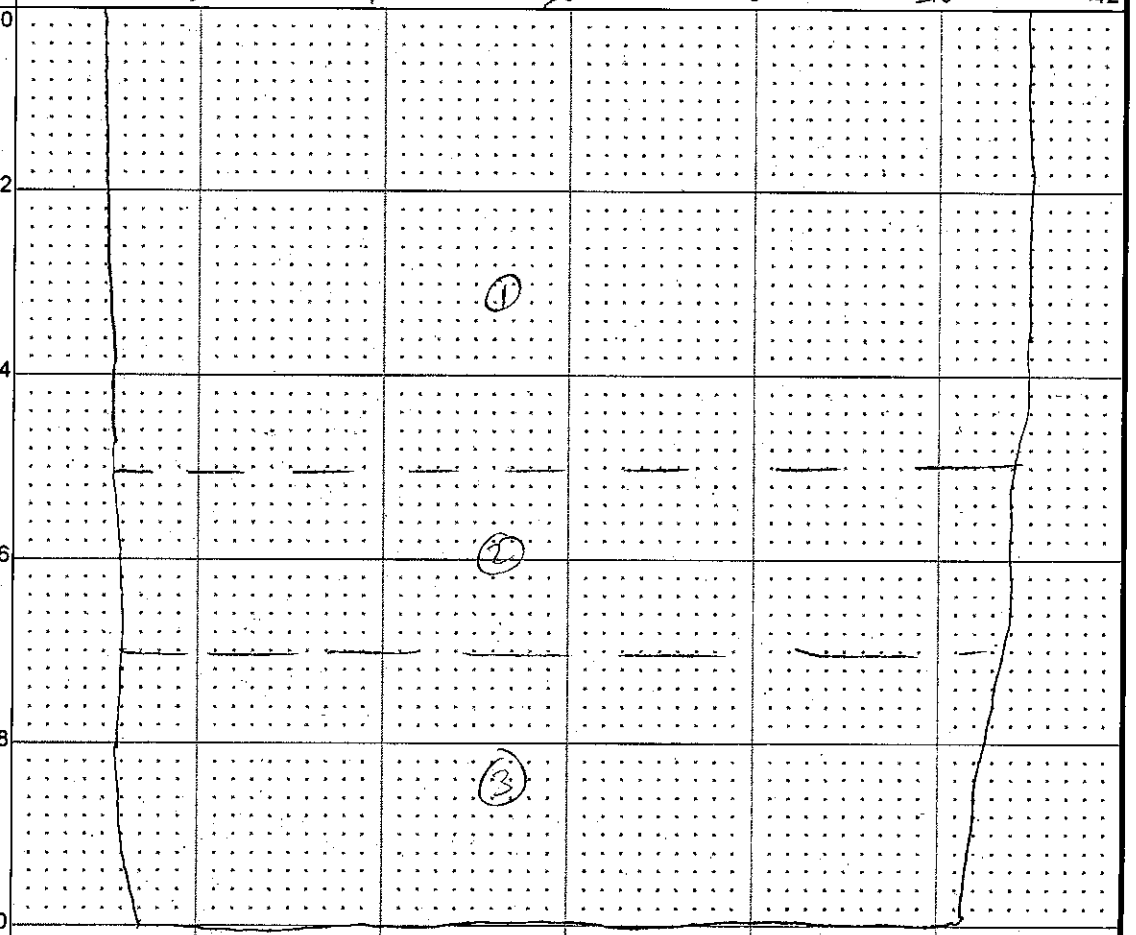


FIG. 1

NOTE

1. Test pit dimensions measured approx. 15 ft long, 10 ft deep and 3 ft wide.
2. Approx. surface elevation was estimated based on survey stakes.
3. Test pit failed immediately after completion of excavation.

FIELD LOG OF TEST PIT

LOGGED BY: J.F. SUBCONTRACTOR: _____

JOB NO: PS20203780 DATE: 10/7/21 LOCATION: TSNW 7.15R

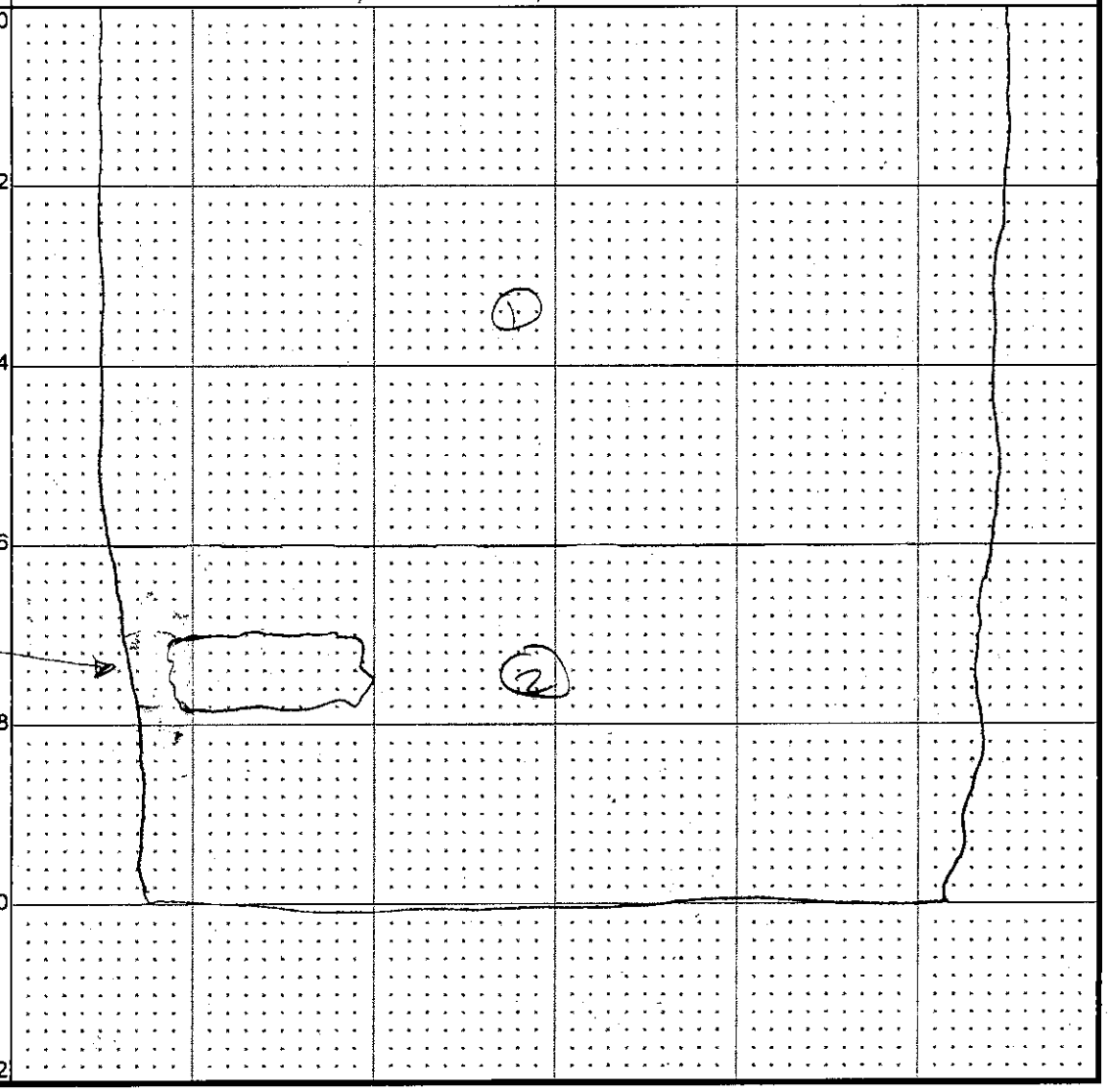
LOG OF TEST PIT TP-2

PROJECT: I-405 RTB

SOIL DESCRIPTION	Ground Water	% Water Content	Samples	Depth, Ft.
(1) SILTY SAND with GRAVEL (SM) - moist, brown, fine to medium grained, some roots, minor angular cobbles.				0
(2) Alternating layers of SILT (ML), moist, appears stiff, gray, few fine grained sand, clayey				2
				4
At approx. 7 ft: encountered asphalt.				6
				8
				10
				12

Sketch of West Pit Side — Surface Elevation: Approx. 69 Ft.

Horizontal Distance in Feet: 0, 3, 6, 9, 12, 15, 18



NOTE

1. Test pit dimensions measured approx. 15 ft long, 10 ft deep, and 2½ ft wide.
2. Approx surface Elevation was estimated based on survey stakes.

FIG. 2

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Special Inspection Report

PROJECT NAME WSDOT I-405 Renton to Bellevue Design Build		PROJECT NO. PS20-20378-0	FIELD REPORT NO. 2021-10-08~JF T. SOIL NAIL WALL 07.15R
ADDRESS 07.15R: Temp Soil Nail Wall		DATE October 8, 2021	PAGE 1 OF 4
CITY OR COUNTY Renton, WA	PERMIT NO.	ARRIVAL TIME 2:30PM	DEPARTURE TIME 3:00PM
CLIENT WSDOT	WOOD ENGINEER OF RECORD/PHONE NO. Milan Radic / (425) 589-4202		
GENERAL CONTRACTOR FLJV/ Billy Myers (360) 515-8657	WOOD FIELD REPRESENTATIVE/ MOBILE NO. Jimmy Francisco / (323) 203-5126		
SUBCONTRACTOR Drill Tech Drilling and Shoring Inc./ Bill Creger (510) 598-0609	WEATHER Partly Cloudy, 60's degrees F		
TYPE OF WORK PERFORMED Fill Wall 07.15R: Temporary Soil Nail Wall			
EQUIPMENT USED None			

COMMENTS

Wall 07.15R: Temporary Soil Nail Wall

Wood Environmental & Infrastructure Solutions Inc. (Wood) was onsite to observe caving on test pit TP-2 after 24 hours period. The test pit showed no signs of caving. The location of test pit TP-2 is shown on the Site Plan on Page 2 and depicted in Photo 1. The condition of test pit TP-2 is shown in Photos 1 through 3.

Representatives from Kleinfelder (Jimi) and Drill Tech Drilling (Bill Creger) were there onsite to observe the condition of the test pit.

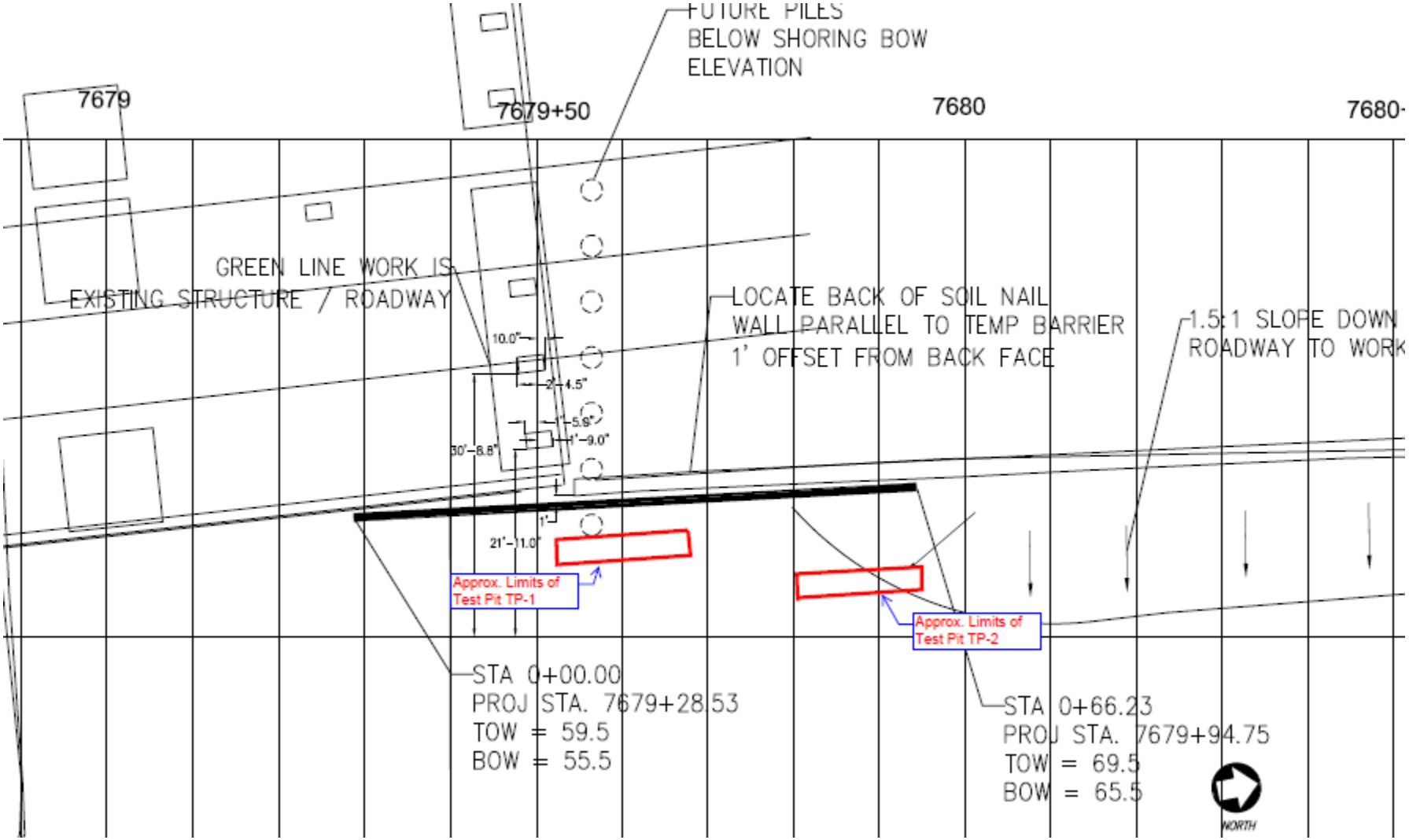
☒ The contents of this field report were discussed with the contractor's on-site representative.

☐ A preliminary copy of this field report was left on site. All recommendations contained herein are subject to change pending review by the WOOD Engineer of Record.

WOOD FIELD REPRESENTATIVE

WOOD ENGINEER OF RECORD

Site Plan: SN2 (partial)



PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
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SN2 partial site plan, provided by Drill Tech Drilling and Shoring Inc	October 8, 2021	2 OF 4

Photo 1: View towards the southwest of test pit TP-2.

PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
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Photo 2: View towards excavation bottom of TP-2 (standing near the north edge of test pit).

Photo 2: View towards excavation bottom of TP-2 (standing near the south edge of test pit).

PROJECT NAME	PROJECT NO.	FIELD REPORT NO.
WSDOT I-405 Renton to Bellevue Design Build	PS20-20378-0	2021-10-08~JF T. SOIL NAIL WALL 07.15R
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Appendix D – B-1-2021 Boring Log

BORING LOG NO. RW-7.15R-TSNW B-1

PROJECT: I-405/Renton to Bellevue-Corridor Widening and ETL

CLIENT: Parsons Transportation Group Inc Phoenix, AZ

SITE: I-405 Renton to Bellevue Renton, WA

LOCATION See Exploration Plan

Latitude: 47.5285° Longitude: -122.1977°

Surface Elev.: 61 (Ft.)

DEPTH	ELEVATION (Ft.)	Description
0.5	60.5	**ASPHALT**, 6 inches of asphalt
		SILTY SAND (SM), fine grained, brown and grayish brown, moist
		trace gravel, medium dense, stratified, intermediate silt layers
		brownish gray, intermediate soft and low plasticity silt layer at top
		olive brown, loose, homogeneous
		trace gravel, brown with gray, medium dense, stratified
		trace gravel, olive brown to brown, stratified, interbedded with gray silt
		trace gravel, brown, stratified, increased silt content
26.5	34.5	***Boring Terminated at 26.5 Feet***

DEPTH (Ft.)	SAMPLE TYPE	RECOVERY (In.)	FIELD TEST RESULTS	SAMPLE ID
5		14	6-8-10 N=18	S-1
			8-19-20-25	S-2
10		15	3-3-4 N=7	S-3
			5-13-15-24	S-4
15		14	8-9-10 N=19	S-5
			7-14-18-24	S-6
20		18	9-9-8 N=17	S-7
			9-15-17-22	S-8
25		15	9-14-12 N=26	S-9

WATER LEVEL OBSERVATIONS, ATTERBERG LIMITS (LL-PL-PI), WATER CONTENT (%), PERCENT FINES

Stratification lines are approximate. In-situ, the transition may be gradual.

Hammer Type: Automatic

Advancement Method:
Hollow Stem Auger

Abandonment Method:
Boring backfilled with bentonite
Surface capped with concrete

See Exploration and Testing Procedures for a description of field and laboratory procedures used and additional data (If any).

See Supporting Information for explanation of symbols and abbreviations.

Notes:

WATER LEVEL OBSERVATIONS

Groundwater not encountered

21905 64th Ave W, Ste 100
Mountlake Terrace, WA

Boring Started: 10-29-2021 | Boring Completed: 10-30-2021

Drill Rig: CME 55 | Driller: Gregory Drilling

Project No.: 81215044